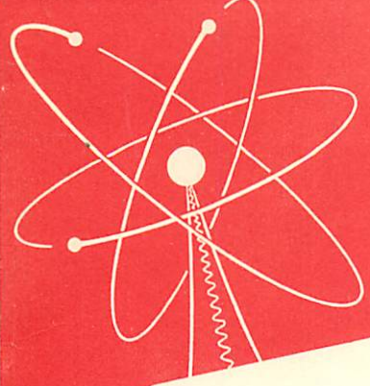

A COMPLETE TV RECEIVER

Lesson T2C-20A

DeVRY Technical Institute
4141 W. Belmont Ave., Chicago 41, Illinois
Formerly DeFOREST'S TRAINING, INC.

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T2C-20A

A COMPLETE TV RECEIVER

DeVRY Technical Institute
4141 Belmont Ave.
Chicago 41, Illinois

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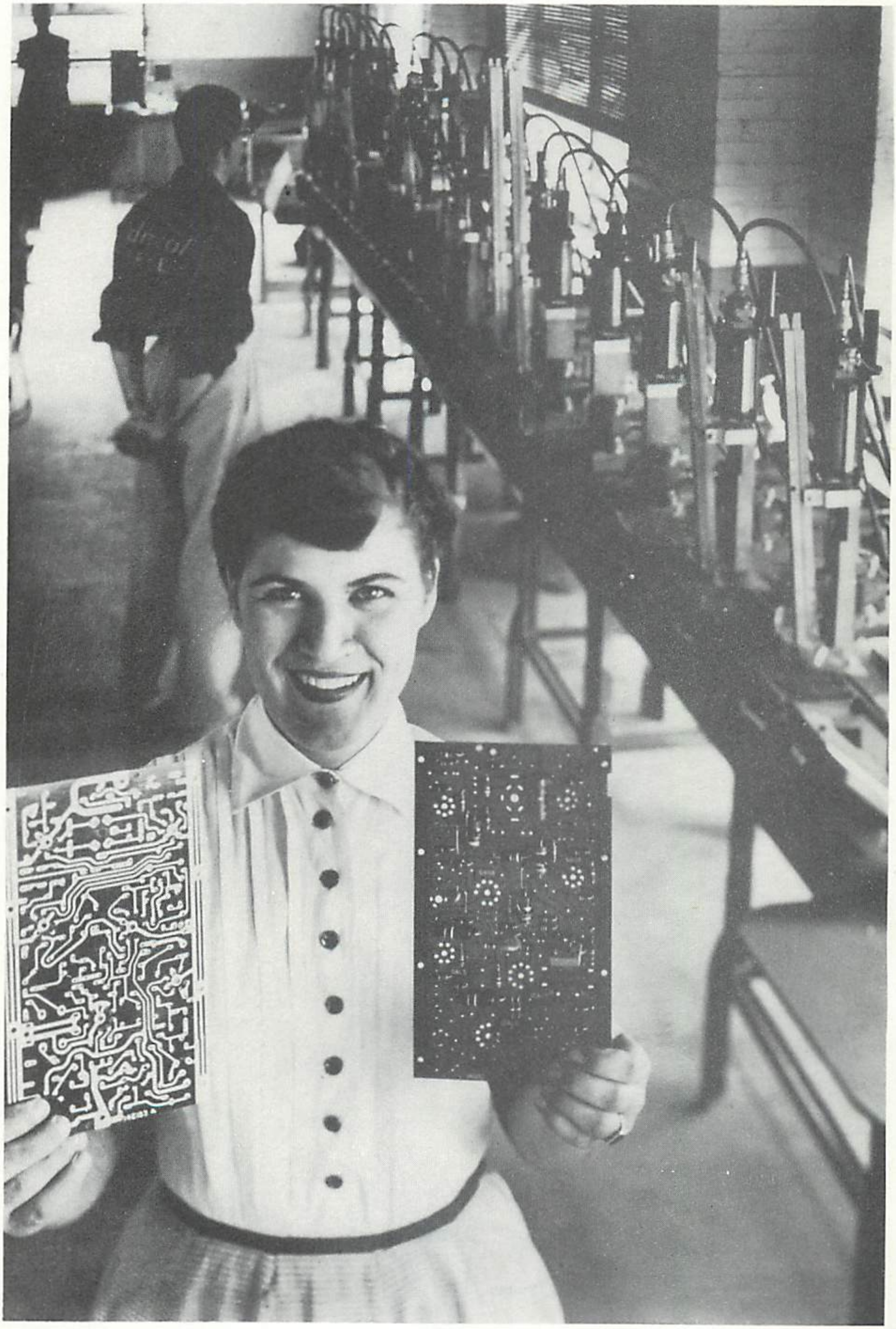

The young lady is holding two samples of printed circuit boards showing top and bottom views; while the machinery for constructing these printed circuit boards is shown in the background.

Courtesy Admiral Corporation

A COMPLETE TV RECEIVER

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Success and true progress are usually strongly flavored with self-restraint; it is a mark of good wisdom. Our modern world has ruled out the man who shoots first and asks questions later.

—H. O. Nelson

A COMPLETE TV RECEIVER

Up to this point, previous lessons included explanations of the sections which make up a complete television receiver. Now, we want to review briefly the overall functions of these sections; to describe the features of automatic gain control, and to acquaint you with the basic ideas of printed circuits. In addition, this lesson includes representative commercial TV circuits. Of course, no single circuit includes all the various features described in preceding lessons, but recognition of how certain circuits function in relation to the entire receiver will enable you to analyze and isolate trouble in almost any complete receiver. Servicing and maintenance instructions comprise the major part of the following lessons in this television series.

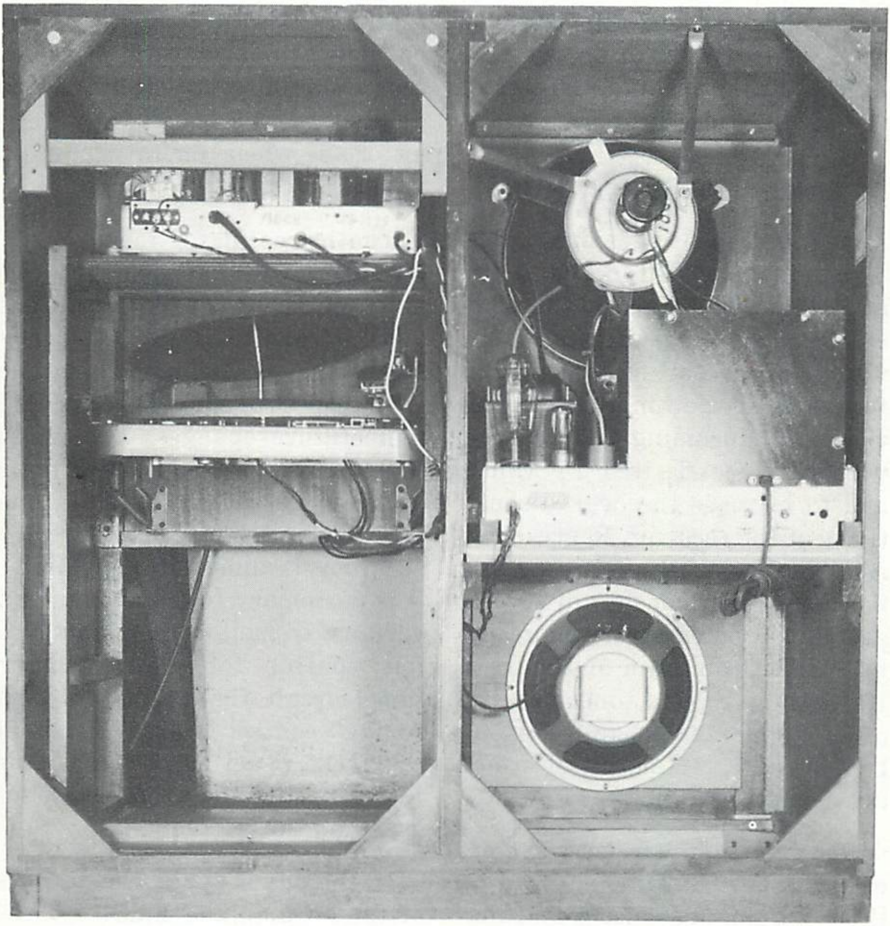
From an electronic standpoint, the television receiver can be considered as a combination of two short wave superheterodyne radio receivers. One converts the video signals into a visible image and the other converts the audio signals into sound. For simplicity in construction and operation, both signals are carried by a single TUNER which usually includes the r-f amplifier, local oscillator and mixer stages.

Like any superheterodyne circuit, most of the gain occurs in the i-f amplifier after which the video and audio signals are demodulated separately. The video signals are converted into a visible image by a cathode ray picture tube which, for proper operation, requires vertical and horizontal deflection generators as well as a high voltage power supply. The audio signals are converted to sound by the conventional type of speaker.

With respect to the division of the video and audio signals, there are two general types of television receivers, known as DUAL CHANNEL and INTERCARRIER. In the dual channel type, shown by the block diagram of Figure 1, the video and audio modulated intermediate frequencies are separated at the output of the r-f tuner and pass through separate i-f amplifiers before being applied to the respective detectors. In some dual-channel receivers, the picture and sound i-f carriers pass through one or more common i-f amplifier stages before being separated.

However, in the intercarrier type receiver, Figure 2, both i-f carriers pass through the entire i-f amplifier and are applied to the video detector. In the video detector, the two waves heterodyne to produce a beat equal to their frequency difference of 4.5 mc. This 4.5 mc wave carries the sound signal frequency-modulation, and therefore serves as a second sound i-f carrier. From the output of the video detector, or after passing through a v-f amplifier stage, the 4.5 mc carrier is carried through the 4.5 mc i-f amplifier and then applied to the audio detector.

In both the dual-channel and intercarrier type receivers, the demodulated video and audio signals are amplified in one or more stages of v-f and a-f amplification, respectively. The video signal is then applied to a control electrode of the picture tube electron gun, and the audio signal to



The rear view of a radio-phono-television combination. Notice the television receiver on the right just above the speaker. The picture tube is mounted by brackets to the cabinet rather than on the chassis.

Courtesy Philco Corp.

the voice coil of the speaker. In both receivers also, the v-f amplifier output is applied to the sync and deflection circuits where the vertical and horizontal sync pulses are separated from the picture signal and blanking pulse components and employed to control the frequencies of the respective deflection generators. Finally, the deflection circuits develop sawtooth currents to produce the desired linear scanning motion of the picture tube beam.

RECEIVER R-F TUNER

As explained previously, one function of the r-f tuner is to permit the receiver to accept the available carrier waves from any television broadcast station. Other functions of the tuner are to convert the incoming r-f carrier waves to the desired i-f values and to increase the overall sensitivity of the receiver. Represented as a single block in Figures 1 and 2, the r-f tuner consists of several stages as shown in the more detailed block diagram of Figure 3. Here, the complete tuner consists of an R-F AMPLIFIER, an H-F OSCILLATOR and a MIXER, all of which are connected to a TUNING DEVICE.

Receiving the carrier wave energy from the antenna lead-in, the r-f amplifier selects and amplifies the desired 6 mc band of frequencies and applies the amplified energy to the input of the mixer stage. In some receivers, the antenna lead-in connects directly to the mixer input but the r-f amplifier has several important advantages. It provides increased image signal rejection. It acts as a buffer, between the h-f oscillator and antenna thereby decreasing the radiation which may cause interference with nearby receivers. Also it provides a higher signal-to-noise ratio because, as an amplifier, an electron tube generates less internal noise energy than when operating as a mixer.

The h-f oscillator must supply the mixer with sufficient r-f voltage to produce a strong i-f output and, in addition, its frequency should be as stable as possible with respect to supply voltage and temperature changes. The maximum allowable frequency drift is on the order of one-tenth of one per cent and since this degree of accuracy is difficult to maintain, it is customary to employ a small variable capacitor as a fine tuning control for the oscillator tuned circuit. Generally, this "fine tuning" control is brought out to the front panel so it can be adjusted by the viewer for each selected station.

In the mixer stage, the outputs of the r-f amplifier and h-f oscillator are heterodyned to produce the picture and sound intermediate frequencies. The difference between the video r-f carrier and the oscillator frequencies is the picture i-f, while the difference between the audio r-f carrier and the oscillator frequencies is the sound i-f. When the oscillator frequency is higher than that of both r-f carrier waves, the higher frequency audio carrier is closer to that of the oscillator and results in the lower difference, or intermediate frequency.

For example, a channel 3 station has a visual carrier frequency of 61.25 mc and an aural carrier frequency of 65.75 mc. If the h-f oscillator, of a receiver tuned to this station, operates at 87 mc, the picture i-f will be $87 - 61.25 = 25.75$ mc, and the sound i-f will be $87 - 65.75 = 21.25$ mc. Notice that the picture i-f is higher than the sound i-f and also that they are separated by 4.5 mc $(25.75-21.25)$. Since the visual and aural r-f carriers are always separated by 4.5 mc, the i-f carriers have this separation also, regardless of the local oscillator frequency.

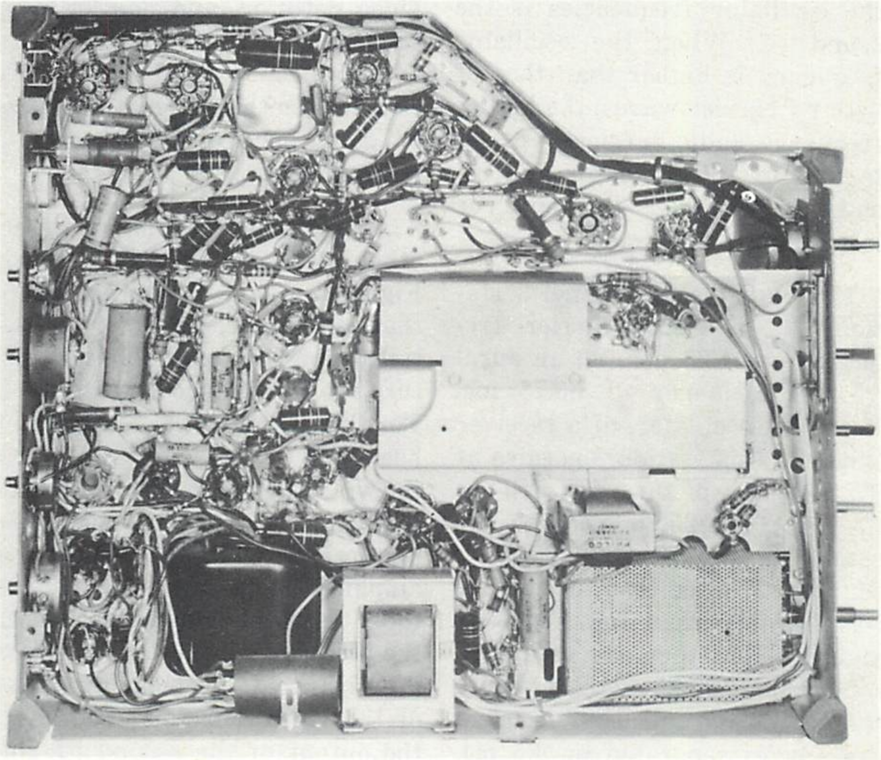
RECEIVER PICTURE CHANNEL

The series of receiver circuits or stages through which the video signal passes from the tuner to the picture tube is called the PICTURE CHANNEL while the SOUND CHANNEL includes the various stages through which the sound signal passes from the tuner to the loudspeaker. The picture channel includes a three to five stage i-f amplifier, the video detector, and one or more stages of v-f amplification. In addition, many receivers contain circuits for the automatic control of gain, picture brightness and noise limiting.

As explained for the r-f tuner, other blocks in the diagrams of Figures 1 and 2 contain more than one stage, and a more detailed diagram of a receiver picture channel is given in Figure 4. For this example, the i-f amplifier has four stages and, following the video detector, the video amplifier has two stages with a d-c restorer between the second v-f amplifier stage and the picture tube. In dual-channel receivers, the picture and sound i-f carriers are separated at some point ahead of the video detector, such as at the output of the second i-f amplifier as indicated. In this case, the first two i-f amplifiers carry both picture and sound i-f signals, and therefore are a part of the sound channel as well as the picture channel.

In the intercarrier type receivers, the sound i-f TAKE-OFF is at some point after the video detector, such as at the output of the first v-f amplifier stage as indicated. In this way, the first v-f stage acts as an additional i-f amplifier for the 4.5 mc sound i-f carrier and, along with the video detector and preceding i-f stages, is a part of the complete sound channel. Thus, in an intercarrier receiver, the video circuits following the sound i-f take-off point constitute the only portion of the picture channel which does not carry the sound signals also.

Finally, the output of the last v-f amplifier stage is applied to the control grid or cathode of the picture tube electron gun and also to the synchronizing circuits. Although omitted in some receivers, the d-c restorer serves to re-insert the d-c component of the video signal which is present in the output of the video detector but cannot be passed by the d-c blocking capacitors in the v-f amplifier coupling circuits. The d-c component of the signal adds vectorially to the control grid bias voltage of the picture tube, and



This underside view is typical of what may be expected in any television chassis.
Courtesy Philco Corp.

thus serves to maintain the black level of the video signal at the picture tube beam cut-off point.

THE I-F AMPLIFIER

The television receiver i-f amplifier selects the desired i-f carrier waves and rejects all undesired components of the mixer stage output. Besides the desired carriers, the mixer stage output contains components at the picture and sound r-f carrier frequencies, the sums of the r-f carriers and local oscillator frequencies, and the difference between the frequencies of the picture and sound carriers.

In each 6 mc television channel, the picture carrier is 1.25 mc above the lowest frequency and the sound carrier is .25 mc below the highest frequency. Thus, with respect to any particular channel, the sound carrier of the adjacent lower frequency channel is 1.5 mc below the picture carrier. Also, the picture carrier of the adjacent higher frequency channel is 1.5 mc above the sound carrier. The broadly tuned r-f circuits will accept these adjacent channel carriers which will heterodyne with the receiver oscillator and produce beat frequencies 1.5 mc above the desired picture i-f and 1.5 mc below the desired sound i-f.

To reduce this type of interference, the FCC does not assign adjacent channels to transmitters operating in the same service area. However, in some receiver locations, there may be overlapping of signals from two or more transmitters on adjacent channels, when the transmitters themselves are located in different service areas. Therefore, the receiver i-f amplifier must be designed so that it has the ability to reject any such undesired beat frequencies.

To attenuate these undesired frequencies, many television receivers employ special series or parallel tuned circuits associated with the i-f amplifier interstage coupling or cathode circuits. Known as a TRAP, each of these sharply tuned LC circuits either rejects or provides a low reactance path to ground for the particular frequency to which it is tuned.

The picture i-f amplifier stages must have uniform response over a sufficient range of frequencies so that they are capable of passing all or a substantial part of the picture i-f band. Since the small details in the reproduced image correspond to the sideband components farthest removed from the i-f carrier, the picture quality or definition in any particular receiver depends upon the frequency band over which its i-f amplifiers and other picture channel circuits have uniform response.

As in any type of amplifier, the picture i-f amplifier bandwidth is inversely proportional to gain. That is, its bandwidth can be increased at the expense of gain, or the gain increased at the expense of bandwidth. In various receiver designs, the total gain of the picture i-f section must be anywhere from 1000 to 10,000, or more. Thus to provide both the maximum frequency response and the required gain, some television receiver models contain as many as four stages of picture i-f amplification. However, other models are designed with fewer i-f amplifier stages in which the frequency response has been reduced to some extent to provide the needed amount of total i-f gain.

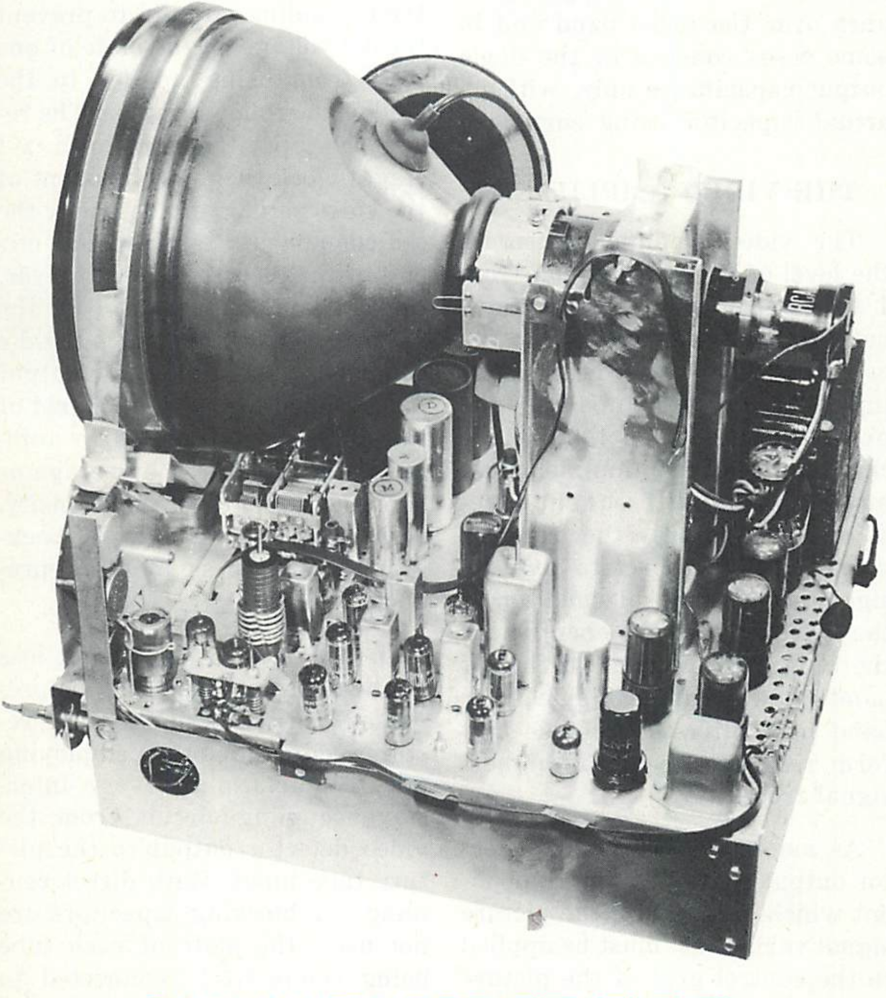
Besides the picture i-f carrier and its sideband components, in an intercarrier type receiver the i-f amplifiers must pass a certain amount of energy at the sound i-f carrier and sideband frequencies. However, the i-f amplifiers must have considerably less response to the sound i-f carrier than to the picture i-f carrier. This condition is necessary so that the 4.5 mc second sound i-f carrier—produced in the video detector—will not be amplitude modulated to any great extent by the picture signals. Therefore, in the intercarrier receiver i-f amplifier stages, the response to the sound i-f carrier is only 10% or less of the maximum response to the picture i-f band.

In those i-f amplifier stages which carry both picture and sound i-f signals in a dual-channel type receiver, the response to the sound i-f carrier is much lower than it is to the picture i-f band. This is necessary to prevent excessive sound i-f signal voltage being applied to the video detector. For the same reason, a sharp cutoff in response at the low frequency end of the picture i-f passband is employed in the amplifier stages which carry the picture i-f signals only. To aid in the attenuation of the sound i-f in these picture i-f stages, many television receivers contain LC trap circuits like those mentioned above, but which are tuned to resonance at the sound i-f carrier frequency.

THE VIDEO DETECTOR

Operating on the same principle as the detector in an AM broadcast radio receiver, the video detector demodulates the picture i-f carrier to recover the video signal. In the detector circuit, a diode tube or a crystal serve to rectify the applied i-f signal and a low pass filter eliminates the intermediate frequency components, so that the output consists of the composite video signal only. Since the average amplitude of the carrier is proportional to the brightness of the scene being televised, the video signal d-c component is present in the output of the video detector. Therefore, the various components of the video signal have the same relative amplitude at this point that they had at the input to the transmitter modulated stage.

For proper operation, the video detector should not load the preceding i-f stage or the following v-f amplifier. Also, the detector input and output coupling circuits must have a 3 to 4 mc response to pass the entire applied i-f band as well as the output v-f band. To



The chassis of a nationally advertised receiver. Notice the tuner in the front left corner.

Courtesy Wilcox-Gay Corp.

meet these various requirements, the video detector has a relatively low resistance load resistor, and its output circuit contains peaking coils or a band pass filter. To prevent attenuation of the higher video frequency components, the capacitance in shunt with the load resistance must have high reactance over the video band and in some cases consists of the diode output capacitance only, with no actual capacitor being employed.

THE VIDEO AMPLIFIER

The video amplifier increases the level of the video signal from 1 to 3 volts rms at the detector output to a level of from 30 to 100 or more volts peak-to-peak at the input to the picture tube. Like the preceding stages of the picture channel, the video amplifier must have wideband frequency response. Therefore, the receiver video amplifier circuits are designed to minimize attenuation of the video signal components near the high and low ends of the v-f band, and contain peaking coils or band pass filters to provide uniform response up to the highest signal frequency.

As mentioned, the video detector output contains a d-c component which, along with the picture signal variations, must be applied to the control grid of the picture tube. This is necessary so that the background of any reproduced scene will have the correct brightness level, and the various details of one scene will have the correct brightness level with respect to the details of another scene.

Like the usual resistance coupled a-f amplifiers, most v-f stages employ d-c blocking capacitors in their coupling circuits to prevent the d-c voltage on the plate of one tube from being applied to the grid of the following tube. The resistance-capacitance coupled v-f stages block the d-c component of the video signal, and pass only the a-c components to the input circuit of the picture tube. However, the d-c voltage produced by the restorer is proportional to the d-c component in the detector output and, applied to the control grid of the picture tube, serves to automatically regulate the average or reference level of beam intensity, resulting in the correct background brightness in the reproduced image.

In the receiver v-f stages, loss of the d-c component may be prevented and the need for a d-c restorer eliminated by employing DIRECT-COUPLING in every interstage coupling circuit from the video detector output to the picture tube input. With direct coupling, d-c blocking capacitors are not used, the plate of each tube being conductively connected to the grid of the following tube. Thus, the d-c component of the video signal is passed along with the a-c components and applied to the picture tube control grid.

With this arrangement, the grid of each tube obtains its d-c operating voltage from the same source as the plate of the preceding tube and, at the same time, the proper voltage relationships exist between the elements of each individual tube. To provide for these voltage relationships, the receiver power supply must contain a suitable voltage divider circuit, at different points on which all the various operating voltages are available.

RECEIVER SOUND CHANNEL

The block diagram of a television receiver sound channel is shown in Figure 5. In the dual-channel type receiver, this diagram represents either the entire sound channel, or that part of it following the sound i-f take-off point when the receiver contains one or more i-f stages which carry both picture and sound i-f signals. In the intercarrier type receiver, however, the diagram of Figure 5 represents only that part of the sound channel which carries the second or 4.5 mc i-f carrier, and the a-f signal.

In either type of receiver, the amplitude of the input signal is increased by one or more i-f amplifier stages and then demodulated in the audio detector stage. This stage may be a discriminator, a ratio detector or a gated beam detector, the operations of which have been explained in previous lessons. Briefly, these FM detectors are designed and arranged so that their output contains an a-f voltage component which corresponds to the frequency-modulations of the input signal.

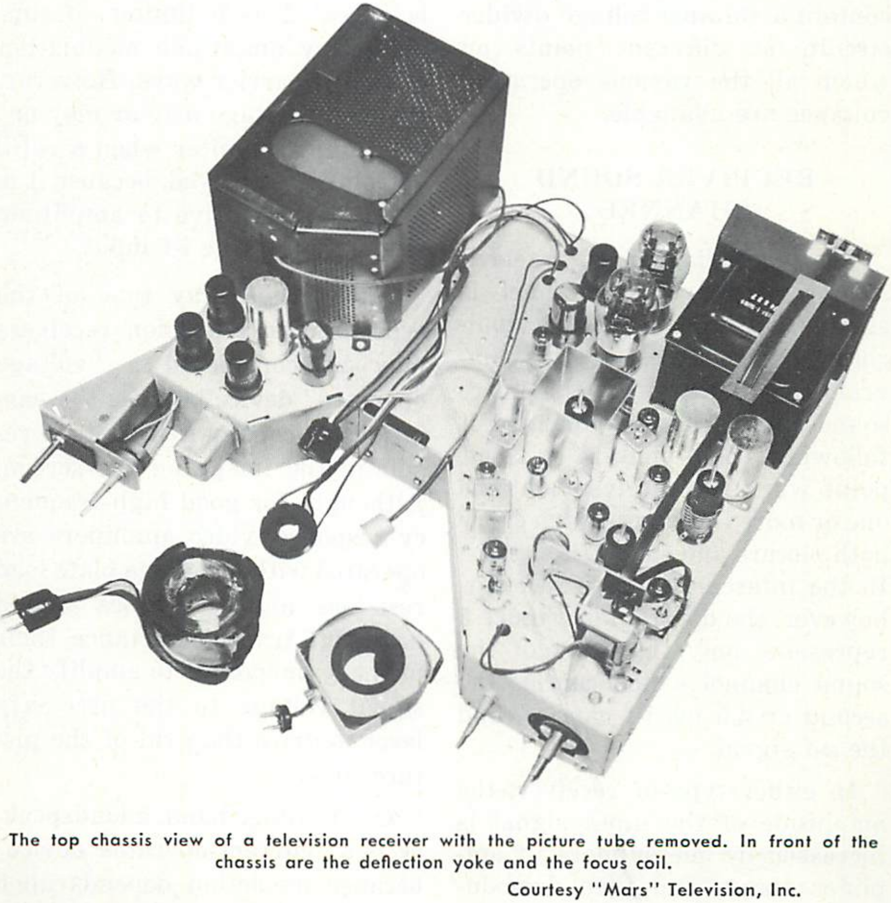
With a discriminator type of detector, the preceding i-f stage is operated as a limiter to suppress any amplitude modulation of the i-f carrier wave. However, the final i-f stage may or may not operate as a limiter when a ratio detector is employed, because it is much less sensitive to amplitude modulation of the i-f input.

Any cathode ray tube of the type used in television receivers may be considered a "voltage operated" device because the variations of control grid voltage result in the image on the screen. Although, for good high-frequency response, video amplifiers are operated with low value plate load resistors and the tubes should have high transconductance, their primary purpose is to amplify the signal voltage to the necessary level to drive the grid of the picture tube.

On the other hand, a loudspeaker is a "current-operated device" because its action depends upon audio frequency variations of the current in its voice coil. Thus, as indicated in Figure 5, the second a-f amplifier stage consists of a power amplifier which serves to produce large variations of current in its output or plate circuit.

SYNCHRONIZING AND DEFLECTION CIRCUITS

In Figures 1 and 2, a single block represents all of the various receiver circuits which produce the picture tube deflection currents as well as those that control the frequencies of the deflection current generators. A more detailed block diagram of these circuits is given in Figure 6, where the video signal from the receiver v-f amplifier is applied to the sync clipper which acts to eliminate the picture signal and blanking pulse components, and am-



The top chassis view of a television receiver with the picture tube removed. In front of the chassis are the deflection yoke and the focus coil.

Courtesy "Mars" Television, Inc.

plifies only the sync pulses. The amplitude of the horizontal and vertical sync pulses is increased in the sync amplifier stage, the composite pulse output of which is applied to a pair of filters.

Shown in the upper right of the diagram, the low-pass filter blocks the 15,750 cps horizontal sync pulses, but passes the 60 cps vertical sync pulses to the control grid circuit of the 60 cps vertical deflection oscillator. This oscillator produces an alternating voltage having a sawtooth or trapezoidal waveform which, applied to the grid of the vertical deflection amplifier, causes sawtooth current in the plate circuit of this tube. The sawtooth plate current is coupled through an output transformer to the vertical deflection coils of the picture tube yoke.

Shown at the left end of the second line of blocks, the high-pass filter permits only the 15,750 cps horizontal sync pulses to reach the horizontal frequency control circuit. This circuit compares the frequency of the sync pulses with the output of the 15,750 cps horizontal deflection oscillator, and develops a d-c output which is employed to control the frequency of the oscillator. As in the vertical deflection circuit, the horizontal deflection oscillator produces an alternating voltage with sawtooth or trapezoidal waveform which is employed to drive the horizontal deflection amplifier.

Having a frequency of 15,750 cycles per second, the sawtooth output current of this amplifier is coupled through an output transformer to the horizontal deflection coils of the picture yoke. Thus, both pairs of coils in the yoke are supplied energizing currents of the proper frequencies and waveform to provide the desired deflection of the electron beam.

POWER SUPPLIES

In this overall review of the function of separate sections of a complete television receiver, references to the power supplies have been omitted. As long as the proper operating voltages are supplied, the actual method of obtaining the necessary voltage is not directly related to the operation of the TV receiver.

Normally the TV receiver power supply consists of (1) a low voltage supply similar to that employed in radio receivers and audio equipment, and (2) a high voltage supply known as the flyback type because high positive pulses, which are rectified and filtered, are obtained from the horizontal output circuit during the flyback or retrace portion of the sawtooth deflection current. Power supply details can be recalled by reviewing an earlier lesson on the subject.

AUTOMATIC GAIN CONTROL

The avc (automatic volume control) circuits in a radio broadcast receiver function automatically to vary the gain of the controlled stages. As a result, the gain is inversely proportional to the received carrier strength. The change in amplification is accomplished by operating remote cutoff type amplifier tubes with a grid bias voltage which is directly proportional to the average carrier amplitude. An increase in average carrier strength produces an increase in negative grid bias, thereby causing the amplifier tubes to operate on a less steep portion of their E_cI_b characteristics and produce less signal amplification. This amounts to varying the gain of the amplifier stages. The basic principle is used in television receivers as well.

Some of the different types of automatic gain control circuits have been explained in previous lessons. However, because of the importance of these circuits and to maintain continuity of the added explanations, a few agc circuit details are reviewed in this lesson.

In the block diagrams of Figures 1 through 6, a function block labeled AGC has not appeared. Therefore, to illustrate the relative position of an agc circuit, the block diagram of Figure 7 shows its relationship to the r-f, i-f and video detector circuits in the receiver picture channel of a commercial receiver described later in this lesson. Here, the output of the video detector, besides being applied to the video amplifier, is fed to the agc system, which, in turn, applies a negative voltage to the grids of the r-f and i-f amplifiers.

Figure 8 is a simplified schematic diagram of an agc system designed to operate on the average amplitude of the received carrier. The modulated i-f signal is fed to the cathode of the video detector and the composite video signal is obtained in its plate circuit as shown. At the ungrounded end of the 6.8 k load resistor, the signal is pulsating d-c and the d-c portion is negative in respect to ground. The pulsations are filtered out and the negative voltage is fed to the grid return points of the controlled stages.

The 390 k resistor forms a voltage divider with the 560 k resistor to reduce the agc voltage to the desired level. The 1000 ohm resistor and the .001 μf capacitors are high frequency filters which prevent the i-f signal in one stage from interacting with the other stage.

In the transmission of television signals, the carrier average amplitude is purposely made to vary in accordance with the average background brightness of the scene, and therefore, it is undesirable that the average carrier strength variations be suppressed in the receiver. For this reason, the television receiver gain control circuit usually differs slightly from that used in the radio broadcast receiver.

The general method employed in the television receiver is to develop a bias which is proportional to the peak instead of the average amplitude of the video carrier. For this reason, when the varying bias depends on the amplitude of the signal peaks, the circuit is more specifically referred to as AUTOMATIC GAIN CONTROL. If no fading or other effect causes a variation in peak carrier strength, this bias and, therefore, the gain of the amplifiers remains constant. However, any peak carrier amplitude change will result in a compensating change of agc bias and signal amplification.

In television transmission, the picture signal blanking level is maintained at a constant carrier level that is equal to 75% of the peak carrier amplitude. Hence, corresponding to the peak carrier level, the tips of the synchronizing pulses always reach a uniform maximum amplitude and afford a convenient reference signal strength for operation of a television agc system.

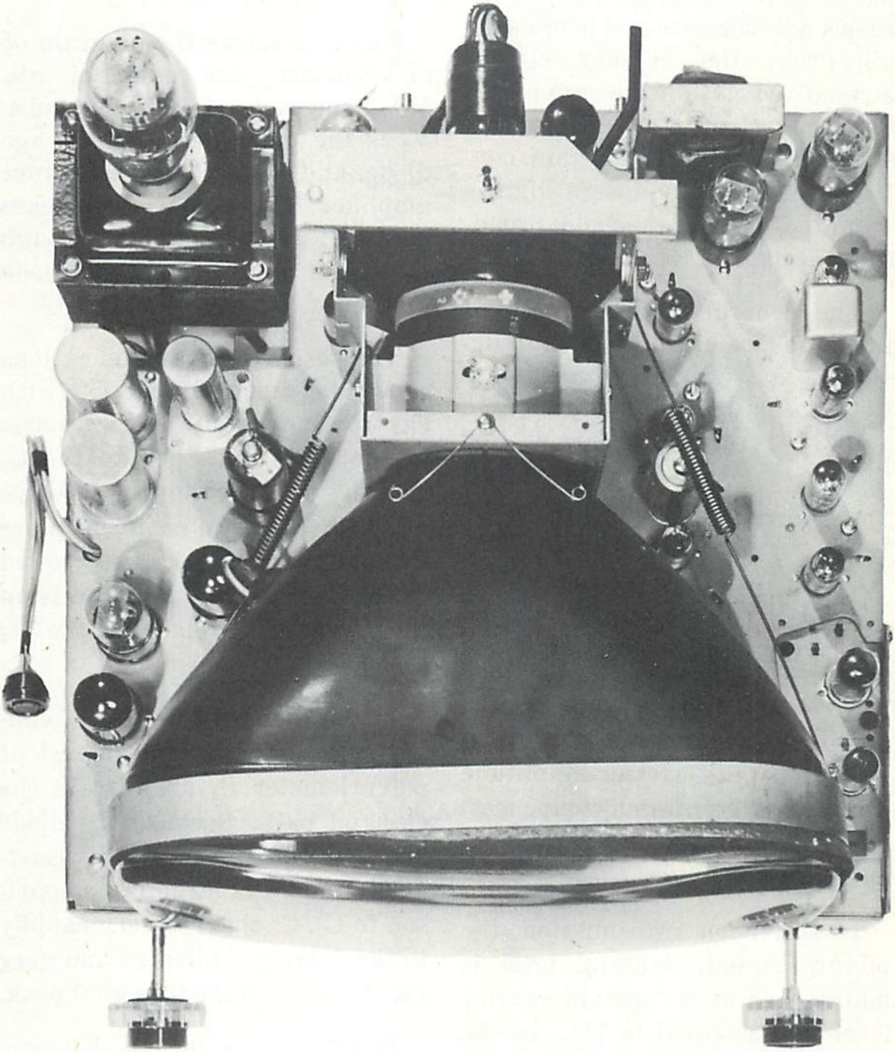
Simple AGC

Figure 9 shows the diagram of an automatic gain control circuit. V_1 is the last i-f amplifier tube, V_2 is the video detector and agc diode, and V_3 is the video output amplifier. The V_1 output appears across L and is coupled through C_2 to the plate of the agc diode section of V_2.

The positive signal alternations cause the diode to conduct, with electron flow from the V_2 cathode to the plate and then to the C_2 negative plate. From the positive plate, the electron path continues through L to ground, from ground to the C_5 negative plate and from the C_5 positive plate to the V_2 cathode.

In parallel with C_5, series connected resistor R_4 and a part of potentiometer P_1 are also in the electron path. Because the diode and coil L have very low resistances and C_5 is large in comparison to C_2, C_2 charges very rapidly to the polarity indicated and very nearly equal to the i-f signal peak.

During the intervals between the i-f signal positive peaks, the diode becomes nonconductive and C_2 discharges through R_3 and the coil L. The resistance of R_3 is made very large so that the discharge circuit time constant is relatively long and the capacitor discharges slowly.



The chassis view of a well known television receiver with a rectangular picture tube, ready to slide in cabinet and ship.

Courtesy Motorola, Inc.

Neglecting the relatively low d-c resistance of L, the positive plate of C_2 is at d-c ground potential while the other plate is negative with respect to ground by the d-c value, e_{c_2}. Thus, for simplicity, it might be assumed that a battery with voltage e_{c_2} is connected with its negative terminal to the plate of the agc diode and its positive terminal to ground. This negative bias on the plate permits conduction of this tube only during the sync pulse intervals when the signal is most positive.

The tops of the sync pulses are equal to the peak carrier amplitude, any variation of which varies the amount of the agc diode conduction and the developed voltage e_{C_2}. From the junction between C_2 and R_3, the negative direct voltage e_{C_2} is applied through the filter $R_2C_4R_1C_3$ to the grid circuits of the r-f and i-f amplifiers as indicated. Thus, an increase in the i-f amplifier output peak causes greater conduction of the agc diode and an increase in negative agc bias voltage e_{C_2}. Applied to the r-f and i-f amplifier tube grid, the increase in negative bias reduces the amplification in these stages. In a similar manner, a decrease in the signal peak causes less conduction of the diode, a decrease in e_{C_2}, and an increase in the r-f and i-f amplification.

In the circuit of Figure 9, potentiometer P_1 serves as the contrast control, permitting variation of the magnitude of the developed agc bias and the self-bias in the cathode circuit of video frequency output tube V_3. Resistor R_5 and the part of P_1 between it and the slider form a voltage divider between B+ and ground. Connected through R_4 to the junction between R_5 and P_1, the cathode of the agc diode has a d-c bias which is positive with respect to ground.

When the slider is moved toward R_4, this positive bias is reduced and the conduction of the agc diode is increased. This action causes a higher agc voltage which decreases the amplification in the r-f and i-f amplifier stages. This same adjustment of the slider results in a greater resistance in the V_3 cathode circuit, increasing the bias and reducing the amplification in this stage. The reverse is true also. Moving the contrast control slider toward R_6 causes an increase in amplification by the r-f, i-f, and video output stages.

Amplified AGC

Some receivers incorporate an agc voltage amplifier to increase the sensitivity of the system and, as an example of this arrangement, Figure 10 shows another agc circuit. Here, V_1 is the last i-f amplifier tube, V_2 is the video detector and agc detector, V_3 is the agc amplifier and V_4 is the agc diode.

In order to produce the desired bias, this entire circuit is operated below ground potential and is supplied with negative d-c operating voltages from the power supply. In operation, the i-f signal that is developed across coil L_1 is coupled through C_2 to the agc detector, where the positive signal alternations cause the tube to conduct and charge C_3 to a value e_{c_3} which is nearly equal to the i-f signal peak.

The agc detector output, e_{c_3} is applied through the long time constant filter $R_3R_4C_4$ to the grid of V_3 which operates as a direct coupled amplifier. As shown, the V_3 plate connects through R_{10} and R_{11} to ground. However, normal operation of this tube is obtained since its cathode is connected to the slider on potentiometer P_1, and, as indicated, it is 99 volts negative with respect to ground. Likewise, returned through R_4, R_3 and R_2 to the -105 volt power supply terminal, the V_3 grid is operated 6 volts negative with respect to the cathode, less the voltage e_{c_3} produced by the received signal.

In series in the V_3 grid-cathode circuit, e_{c_3} opposes the applied fixed bias, therefore the net negative grid bias varies with e_{c_3}. The V_3 plate current in R_{10} and R_{11} causes voltages that make the V_3 plate negative with respect to ground. The negative voltage at the junction of R_{10} and R_{11} is filtered by C_7, which charges to the polarity shown, and is applied to the grid return of the r-f amplifier tube.

Capacitor C_6 is connected across both resistors and charges to their total voltage with the polarity shown. The voltage across C_6 is applied through filter R_9C_5 to the grid returns of the if amplifier tubes.

In operation, an increase in the i-f signal peak causes greater conduction of the agc detector during the sync pulse intervals, charging C_3 to a higher voltage. The increase of e_{c_3} makes the V_3 grid less negative, increasing the plate current and, therefore, the voltage across R_{10} and R_{11}. This action results in an increase of the e_{c_6} and e_{c_7} negative agc voltages, which reduce the signal amplification in the r-f and i-f stages of the receiver.

On the other hand, when the signal peak decreases, e_{c_3} is reduced, V_3 plate current decreases, and the reduction of voltages e_{c_6} and e_{c_7} permit greater amplification in the r-f and i-f stages. The long time constant filter $R_3R_4C_4$ prevents rapid changes of the V_3 bias so that rapid changes in signal strength do not cause changes in the i-f and r-f amplifier bias voltages. The operating voltage of the V_3 cathode can be changed by means of the contrast control potentiometer P_1, thereby permitting manual adjustment of the agc voltages developed.

Since capacitor C_6 is connected across both R_{10} and R_{11}, a higher voltage is developed across it than across C_7. For very high input signal amplitudes, the agc bias applied to the i-f amplifier grids may be so high as to cause the tubes to operate near the cut-off point and distort the signal. To prevent this distortion, agc diode V_4 is employed to limit the amount of bias applied to the i-f amplifier tubes by connecting its cathode to the i-f agc line and its plate to a -7.2 volt power supply terminal.

Normally, the V_3 plate and therefore the V_4 cathode is less negative than -7.2 volts, and V_4 is nonconductive. However, when e_{C_6} exceeds -7.2 volts, the V_4 cathode becomes more negative than the plate and the diode conducts. When conductive, a diode has relatively low resistance and resistor R_9 and the V_4 plate resistance form a voltage divider from the negative plate of C_6 to the -7.2 volt terminal. The i-f agc line is connected to the junction between V_4 and R_9, therefore, when V_4 is conducting, the voltage applied to the i-f amplifier grids will be only a fraction of the total voltage across C_6. That is, after e_{C_6} reaches -7.2 volts, there is a considerable reduction in the rate of agc voltage rise.

The V_3 diode plate circuits prevent changes in agc voltage due to high amplitude transient voltages arising from automobile ignition "noise," etc. Such voltages cause sudden heavy conduction of the agc detector, and voltage e_{R_2} becomes sufficiently high to make the diode plates of V_3 positive with respect to the cathode. The resulting electron flow, from the cathode to the diode plates, cause voltages across R_2, R_3, R_4, R_5 and P_1; all of which are of a polarity which tends to make the grid negative with respect to the cathode and prevent a rise of V_3 triode plate current.

The agc circuits just described are fairly satisfactory when all stations can be received with minimum noise and when changes in signal strength occur slowly. The filter networks that smooth out the agc voltage must have RC time constants sufficiently long to remove the 60 cycles per second vertical synchronizing pulses. Therefore, when the changes in signal strength occur in about 1/60 of a second, or faster, the bias voltage does not change at all.

Another serious drawback is present when the noise level is very high. The noise itself produces a more negative bias and thus reduces the gain of the controlled stages. In areas where a weak signal station is received with a high level of noise, there is a tendency to suppress the television signal altogether, since the noise can produce a bias voltage so large that the already weak signal does not receive sufficient amplification.

Keyed AGC

In an effort to overcome these drawbacks, a fast acting agc circuit has been developed. Known as KEYED AGC, this system employs a pentode type tube, the plate voltage of which is obtained from a pulse developed in the horizontal sweep circuit during the flyback interval. Thus, the tube conducts for only a brief instant, and develops an agc voltage that is proportional to the sync pulse amplitude and is relatively independent of the noise voltage superimposed on the received signals.

The well designed cabinet of the modern television receiver and the simple controls conceal the elaborate circuits necessary to reproduce a good picture.

Courtesy Zenith Radio Corporation

The agc voltage smoothing filter must have an RC time constant only long enough to remove the horizontal sweep frequency, which is 15,750 cycles per second. This short time constant permits the keyed agc circuit to have a fast action.

One important requirement of the keyed agc system is that the composite video signal must be applied to the agc tube so that the sync pulses have positive polarity, that is, the video signal must have negative picture phase.

Another important requirement is that the d-c component be present in the composite video signal applied to the agc tube, otherwise the grid voltage is not the same during each successive flyback period. When the video signal passes through a capacitor, the d-c component is removed and all the sync pulses are no longer at the same level.

To obtain proper operation of this circuit, it is connected to the plate circuit of a video amplifier as shown in Figure 11, where V_3 is the agc tube and V_2 the video amplifier tube. The d-c component of the composite video signal is retained by employing direct coupling between detector V_1 and the video amplifier V_2.

Although capacitive coupling could be employed between V_2 and the picture tube cathode, in this circuit direct coupling is provided by R_9. C_6 is connected in parallel with R_9 to provide high frequency compensation. Except for contrast control P_1 and resistor R_7, the V_1 and V_2 circuits are conventional, with high frequency compensation provided by L_2, L_3, L_4 and L_5 as described in the lesson on video frequency amplifiers.

Potentiometer P_1 is employed to vary the screen grid voltage of V_2 and thus to vary the amplification of this stage. When the slider is moved toward the junction of R_7 and P_1, the screen grid voltage is increased, and this increases the tube transconductance and the stage gain. As the slider is moved toward the junction of P_1 and R_8, the screen grid voltage is reduced so that the transconductance and stage gain are decreased.

R_7 has a low resistance and is connected in series with R_6 to provide the desired amplitude of composite video signal for the agc tube. The V_3 cathode is connected to the junction of R_7 and P_1 and is 140 volts positive with respect to ground. Connected through isolating resistor R_{11} to the junction of R_6 and R_7, the V_3 control grid is negative with respect to the cathode. R_7 is chosen so that the voltage drop across it biases V_3 nearly to cutoff. The screen grid is supplied with a positive 220 volts, while the plate is connected to ground through resistors R_{12}, R_{13}, R_{14} and R_{15}. Therefore the only current in V_3 is a small screen current.

Capacitor C_7 and coil L_6 are connected in series between the V_3 plate and ground. Physically, L_6 is wound on top of the horizontal size control coil L_7, which is connected across part of the horizontal output transformer secondary.

During the horizontal flyback interval, a sharp voltage pulse is developed across L_7 and, by transformer action, across L_6, which is connected so that the pulse is positive on the ungrounded end. Applied through C_7 to the V_3 plate, this pulse has sufficient amplitude to cause V_3 plate current, with electrons flowing from the V_3 cathode to plate and then to the negative plate of C_7. From the other plate of C_7, electrons flow through L_6 to ground, through the power supply to the +140 volt point and then back to the V_3 cathode.

During the period of the sharp pulse on the V_3 plate, the synchronizing pulse, which is part of the composite video signal, appears on the V_3 grid, thus making it more positive and permitting more plate current. Thus the amount of plate current and the charge acquired by C_7 during the sharp plate voltage pulse, depends on the horizontal sync pulse amplitude.

During the interval between the V_3 plate voltage pulses, C_7 discharges through the filter consisting of R_{12}, R_{13}, R_{14}, R_{15}, C_8 and C_9 and through L_6, in a direction such that the junction of C_7 and R_{12} becomes negative with respect to ground. The values of these resistors are chosen so that the desired agc voltages are developed, and then the capacitances of C_8 and C_9 are chosen so that the time constants are long enough to remove the horizontal sweep frequency pulse. To control the gain of the r-f and i-f amplifiers, bias voltages are obtained from the filter as shown in Figure 11.

When the signal strength at the receiver antenna decreases, the amplitude of the sync pulses applied to V_3 also decreases. This results in a decrease in the V_3 plate current so that C_7 is charged to a lower value, less bias voltage is developed, and the gain of the controlled stages is increased to compensate for the loss in signal strength.

On the other hand, when the received signal strength increases, the amplitude of the sync pulses on the V_3 grid also increases. Then C_7 is charged to a higher voltage by the increased V_3 plate current so that the higher bias reduces the gain of the controlled stages.

THE COMPLETE RECEIVER

Now that all of the basic circuits used in a TV receiver have been explained, we want to show how the various stages of a complete receiver are interconnected.

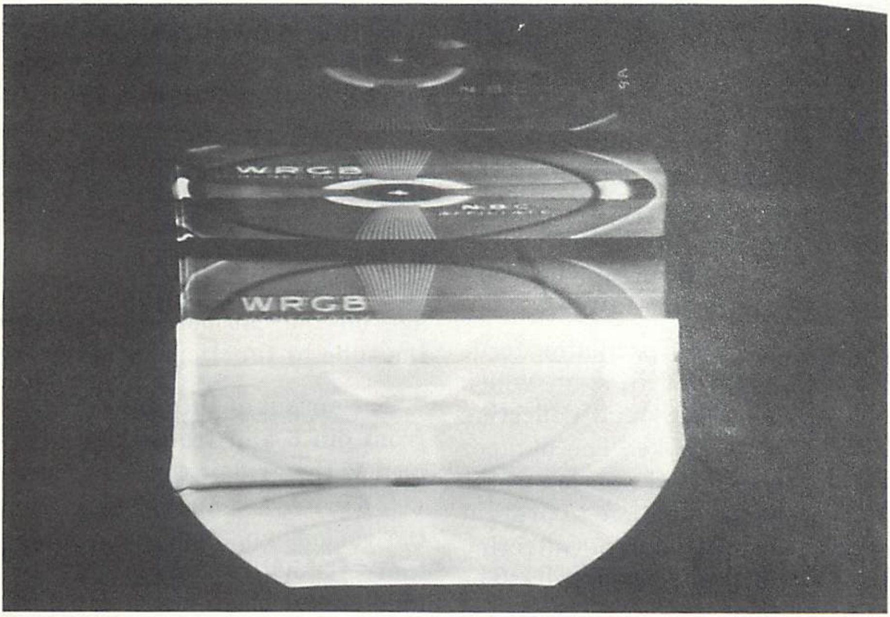
The schematic diagrams of Figures 13, 15, and 19 are typical examples of what will be encountered in the field. It is not intended that the following material explain the circuits in detail as the preceding lessons have analyzed the individual circuits. Also, any unusual circuits or modifications due to production changes which may appear on the diagram will be explained in the lessons dealing with servicing.

Figure 12 is the block diagram of a commercial model TV receiver that is in common use and from the standpoint of being able to analyze the action, it will be of considerable advantage to trace the signals from the antenna to the speaker and picture tube, and follow the control pulses as well. Starting at the antenna input terminals, the r-f signals are amplified by two r-f amplifier stages before they are fed to the mixer and heterodyned with the local oscillator signal. The i-f output of the mixer is amplified by three i-f stages and applied to the video detector.

The sound i-f signal is taken from the video detector and amplified by two stages before being fed to the sound detector. The audio signal output of the detector is amplified by the first audio stage and applied to the sound output amplifier. This last stage amplifies the audio signal still more and provides the power to drive the speaker.

Also obtained at the output of the video detector is the composite video signal that is fed to the video amplifier and finally to the picture tube. The output of the video amplifier also feeds the keyed agc circuit. Working in conjunction with a positive pulse from the horizontal output transformer, the keyed agc system provides the negative bias voltage which is fed back to the grids of one r-f amplifier and two i-f amplifiers. From the output of the video amplifier, the composite video signal is fed to the sync separator which eliminates the video information and blanking pulses from the sync pulses. The sync pulses are then amplified and clipped by the sync clipper and applied to the sync phase inverter.

Positive pulses are obtained from the sync phase inverter and used to synchronize the vertical oscillator. The 60 cps sawtooth pulse from the vertical oscillator then is amplified by the vertical output amplifier and which pro-



Multiple pictures in the vertical direction indicate that the vertical oscillator is operating at too low a frequency.

Courtesy General Electric Co.

vides the deflection power for the vertical windings of the deflection yoke.

Since this particular receiver does not use a d-c restorer, a negative pulse is obtained from the vertical output transformer and applied to the grid of the picture tube. This pulse cuts off the electron beam during vertical retrace time and prevents the retrace lines from appearing on the screen.

Going back to the sync phase inverter, both positive and negative pulses are applied to the horizontal phase detector along with a sample of the horizontal scanning signal from the horizontal output stage. The output of the phase detector is a d-c voltage that is applied to the horizontal oscillator to keep it in synchronization with the sync pulses.

The horizontal oscillator feeds the horizontal output stage which provides the horizontal deflection power for the yoke. The damper tube is related to the action of the horizontal output stage to prevent spurious oscillation from affecting the horizontal sweep circuits. The high voltage rectifier receives a positive pulse from the horizontal output transformer and supplies high direct voltage to the picture tube anode.

AN ADMIRAL TV RECEIVER

To elaborate further upon the receiver arrangement of Figure 12, the complete schematic diagram is shown in Figure 13.

Starting at the antenna, the signal is coupled from the primary to secondary of L_{101} and applied to pin 2 of the 6BZ7 (V_{101}) tube which is a cascode r-f amplifier. Capacitor C_{116} places the grid (pin 7) of the right hand section of the tube at r-f ground and this section functions as a grounded grid amplifier with the signal being applied to its cathode.

Notice that the cathode of the right hand section (pin 8) of V_{101} is about 110 volts positive in respect to ground. In order for this tube to function properly, R_{112} and R_{111} form a voltage divider which applies a positive voltage through R_{110} to the grid (pin 7). This voltage counteracts the positive voltage on the cathode and permits the tube to function normally.

The output of the 6BZ7 is taken from pin 6 and transformer coupled to the grid of the V_{102A} mixer (½ 6J6) by means of L_{102}. Also, the various channels indicated by the coils within the dashed outline, are selected by a revolving turret that changes L_{101} and L_{102} to the proper values depending upon the frequency of the channel selected.

The oscillator signal from V_{102B} is also coupled to the grid of the mixer by means of L_{102} where it beats against the r-f signal to produce the i-f signal in the plate circuit of the mixer. From the plate circuit of the mixer, the i-f signal is coupled to the grid of the first video i-f amplifier V_{301} (6CB6). Coils L_{103} and L_{309} are tuned in conjunction with the coils in the plate circuits of the i-f amplifiers for the proper response.

The wave-traps in the plate circuit of the mixer are adjusted for maximum attenuation of the adjacent channel sound carrier (27.25 mc) and the adjacent channel video carrier (19.75 mc).

Amplified by the first video i-f amplifier, the signal is transformer coupled to the grid of V_{302} (6CB6), the second video i-f stage. In the grid circuit of this stage is another trap tuned to the desired sound carrier (21.25 mc). The purpose of this trap is to attenuate the sound carrier so that it will be the proper amplitude when it is heterodyned with the video carrier (25.75 mc) in the video detector to produce the 4.5 mc sound i-f signal.

The third video i-f amplifier V_{303} (6AG5) along with the V_{302} stage employs stagger tuned transformers so that the frequency response curve has the proper shape. The output of the third i-f amplifier is applied to the cathode of the video detector V_{304A} which is one-half of a 12AT7. Even though this is a triode tube, the grid and plate are tied together and act as the plate of a diode.

The positive picture phase video signal is amplified by video output V_{305} (6CL6) and applied through R_{324} and C_{309} to the cathode of the picture tube. C_{309} permits all of the video signal to be applied to the cathode of the CRT but causes the direct voltage at the plate of the 6CL6 to divide up between R_{324} and R_{325}. Since the video signal is direct coupled from the video detector to the video amplifier and direct coupled from the video amplifier to the picture tube, this arrangement eliminates the need of a d-c restorer.

The CONTRAST CONTROL R_{316}, in the cathode circuit of V_{305}, determines the amount of un-bypassed resistance which causes degeneration and varies the amplitude of the video signal in the 6CL6 plate circuit. BRIGHTNESS CONTROL R_{343} varies the direct voltage on the grid of the picture tube.

Going back to the plate of the video detector, the 4.5 mc sound i-f signal is coupled through C_{201} and L_{201} to the cathode of the first sound i-f amplifier which is the other half of V_{304}. The signal is further amplified by V_{201} (6AU6) the 2nd sound i-f, and fed to the V_{202} (6AL5) ratio detector circuit. After being amplified by RC coupled stages V_{203} and V_{204}, the audio signal is fed to the speaker.

One other circuit associated with the sound i-f signal is the 4.5 mc trap, located in the grid circuit of V_{305}, consisting of C_{322} and L_{308}. The coil is adjusted for maximum attenuation of the sound carrier in the plate of the 6CL6 to prevent the 4.5 mc beat signal from appearing as a fine grain interference pattern on the screen of the picture tube.

At the junction of R_{321} and R_{323}, in the plate circuit of V_{305}, the composite video signal is fed through R_{332} to the grid of the agc keying tube V_{307}. Applied to the plate of this tube is a positive pulse coupled through C_{316} from terminal 7 on the horizontal output transformer. Any variation in the amplitude of the video signal on the V_{307} grid will cause the conduction of the tube to change accordingly and vary the negative voltage obtained at the junction of R_{333}, C_{323}, and C_{317}. These variations of bias voltage are fed through R_{352} to the grids of V_{301} and V_{302} to control their gain.

Located in the V_{307} grid circuit, DX RANGE FINDER CONTROL R_{342} is Admiral's name for the AGC Delay Control and merely varies the direct voltage applied to the grid of the agc tube. As the variable contact is moved to the right, the positive voltage on the grid decreases which increases the bias between the grid and the cathode. This reduces the conduction of the keying tube when the positive pulses are applied to its plate and reduces the agc voltage fed back to the controlled stages. In weak signal areas, the control would be turned to the right and in strong signal areas it would be turned to the left.

Another interesting feature of this agc system is the manner in which the bias voltage for the r-f amplifier is obtained. Resistors R_{350} and R_{351} are connected as a voltage divider between a B+ point and the "minus" voltage developed by the agc tube. The values are chosen so that the voltage at the junction of R_{350} and R_{351} will be negative but smaller in amplitude than that applied to the grids of the i-f amplifiers. Should the agc tube cease conducting, the additional divider network of R_{352} and R_{337} will prevent the agc voltage from becoming exceedingly positive.

The video signal at the junction of R_{321} and R_{322} in the plate circuit of the 6CL6 (V_{305}) also is applied to the grid circuit of the sync separator (pin 2 of V_{403}). The positive signal drives the grid positive in respect to the grounded cathode and electrons flow from cathode to grid which charge C_{308} negative on its bottom plate. This charge biases the tube to cutoff and permits only the sync pulses to cause plate current. This action eliminates the video information and the blanking pulses but the sync pulses appear with negative polarity at the plate of the sync separator. The sync pulses are further amplified and clipped by the sync clipper and applied to the grid of the sync phase inverter V_{401B} (½ 6SN7).

Positive sync pulses from the cathode of the sync phase inverter are applied to the integrator network. Here, the integrated vertical sync pulse triggers the vertical blocking oscillator V_{401A} (½ 6SN7). The free-running frequency of this oscillator is determined primarily by the RC network consisting of C_{404}, R_{448}, R_{404}, R_{457} and R_{405A} the latter being the VERTICAL HOLD CONTROL.

A sawtooth voltage, the amplitude of which is determined by the setting of the HEIGHT CONTROL, is developed across sawtooth forming capacitor C_{414}, and fed to the grid of the vertical output tube V_{402} (6AV5GT). The setting of the VERTICAL LINEARITY CONTROL R_{410}, determines the bias on the 6AV5GT and varies the shape of the current waveform produced by the tube. Vertical output transformer T_{402} is the auto-transformer type and matches the impedance of the yoke vertical windings to the plate impedance of the vertical output tube.

Another feature of this receiver is the **vertical retrace blanking** circuit that has been incorporated. A negative polarity pulse is obtained from the vertical output transformer and fed through C_{406} to the grid of the picture tube. This negative pulse adds to the bias on the grid and causes beam current cutoff during the vertical retrace time. Because of this action, the owner of the receiver can adjust the brightness control to his own satisfaction without having the vertical retrace lines appear.

Color bar generator used for alignment and servicing of color TV receivers.

Courtesy Kay Electric Co.

Referring back to the sync phase inverter V_{401B}, positive sync pulses are coupled through C_{413} to the bottom plate of V_{404} and negative pulses are coupled through C_{412} to the top cathode of V_{404}. The remaining plate and cathode of the double diode are connected together and a negative going sawtooth voltage is applied to them. This voltage is shaped by integrating a positive pulse obtained from the horizontal flyback transformer.

Any deviation of the horizontal oscillator from its correct frequency produces a correction voltage at the junction of R_{426} and R_{427} which is applied through the anti-hunt network, C_{415} and R_{428}, to the grid of the left section of the horizontal multivibrator V_{405} (½ 6SN7). This correction voltage causes the multivibrator to oscillate at the correct frequency. It must be realized, of course, that there is a limit to the amount of correction that can be obtained and the circuit must be designed and adjusted to operate at approximately the correct frequency in order that the afc system can do its job properly.

The components that are the most important in determining the frequency of the horizontal multivibrator are the grid leak capacitor (C_{419}), the fixed grid load resistor (R_{433}), and the variable grid load resistor (R_{405B}). This latter resistor varies the RC time constant and determines the rate that C_{419} can discharge through R_{433} and R_{405B}. The component is a front panel control called the HORIZONTAL HOLD CONTROL.

Stabilization of the oscillator is obtained by inserting resonant circuit L_{401} and C_{418}, tuned to the horizontal scanning frequency, as part of the plate load for the left hand section of this multivibrator. The sine wave developed by this resonant circuit has the positive pulse from pin 2 of V_{405} superimposed on it, as shown by waveform in the schematic diagram, and acts to prevent the free-running frequency of the multivibrator from shifting radically.

A trapezoidal waveform, developed by the sawtooth forming capacitor C_{420} and the peaking resistor R_{438}, drives the horizontal output V_{406} (6CD6G) stage. The HORIZONTAL DRIVE CONTROL, R_{447}, functions along the same lines as the height control. Since sawtooth forming capacitor C_{420} must charge through R_{436}, R_{438} and the horizontal drive control, adjustment of this potentiometer varies the amplitude of the sawtooth portion of the trapezoidal wave applied to the grid of V_{406} and helps to determine the amount of horizontal deflection that is obtained.

The horizontal output (flyback) transformer is the direct drive type with the horizontal windings of the yoke connected from lug 2 of the transformer to one side of the WIDTH COIL and the other side of the width coil connected to lug 3. The damper tube and its filter network (C_{428}, C_{427}, and L_{403}) are connected between lugs 1 and 4 of the transformer.

The secondary of the width coil, L_{402}, is in series with the horizontal windings of the deflection yoke. Adjustment of the width coil helps to determine the overall width of the raster by varying the losses across itself. The HORIZONTAL LINEARITY COIL, L_{403}, varies the phase of the ripple on the B+ boost voltage. This voltage added to the damper tube voltage controls the horizontal linearity.

Even though there is about 695 volts at the cathode of the damper, there is also a pulse of about 2000 volts present that could cause damage to a voltmeter connected to this point. This B+ boost voltage can be measured at lug 4 of the transformer or the common terminal of C_{427} and C_{428}.

The high voltage pulse is rectified by V_{407}, filtered by C_{429} and applied to the high voltage anode of the picture tube.

AN RCA TV RECEIVER

The block diagram of a receiver that also uses many of the common or conventional circuits is shown in Figure 14. In comparison with the Admiral block diagram of Figure 12, this RCA receiver is very similar. However, there are some important differences in the stages used and in the circuits used for the same stages. In particular, the noise cancellation "block" shown between the video detector and 1st sync amplifier requires added explanation.

As shown by the schematic diagram of Figure 15, the r-f section includes a cascode tuner similar to that used in the Admiral but instead of being a turret, it is a switch type tuner. Three video i-f amplifiers (V_{104}, V_{105}, and V_{106A}) are employed, and the signal is demodulated by V_{106B}. Two video amplifiers increase the signal level before it is fed to the grid of the picture tube.

Instead of from the video detector, the 4.5 mc sound signal is taken from the plate of the first video amplifier V_{108A} and fed to the grid of sound i-f amplifier V_{101A}. After being detected by V_{102} and amplified by V_{101B}, the audio signal is fed to V_{103} which furnishes the power to drive the speaker.

The plate circuit of the first video amplifier also is connected through R_{214} to the grid of the keyed agc tube V_{107B}. A positive pulse is obtained from the horizontal output transformer and applied to the plate of the keyed agc tube to obtain the desired action. The amplitude of the agc voltage is determined by the setting of R_{198} and the amplitude of the video signal. In turn, the agc voltage is then applied to the grids of the first r-f amplifier and the first i-f amplifier.

Although labelled AGC DELAY, the crystal diode CR_{101} is also an agc clamping diode. In the circuitry involved, a positive 257 volts is applied through R_{187} to the plate of CR_{101}. Also, R_{190}, R_{191} and R_{188} form a voltage divider to ground which, in the absence of a video signal, tends to make the junction of R_{187} and R_{190} a few volts positive in respect to ground. However, the instant this point begins to go positive, CR_{101} conducts and places it at ground potential. Then, when a sufficiently large video signal is received, the negative voltage developed at the plate of V_{107B} overcomes the positive voltage applied through R_{187}, and CR_{101} does not conduct. Their action permits the negative agc voltage to be applied to the grid of the r-f amplifier in the normal manner.

Noise Cancellation

Going back to video second detector V_{106B}, the negative polarity signal (positive picture phase) is fed to the cathode of noise cancellation tube V_{108B} as well as to the grid of the first video amplifier. Since no polarity reversal takes place when the signal is fed to the cathode, the output of the noise cancellation tube contains negative polarity pulses. Also, NOISE LIMITER CONTROL, R_{207} obtains a negative direct voltage from the grid of the horizontal output tube which is applied as bias to the grid of the noise cancellation tube. This bias is adjusted so that the tube conducts only on pulses which exceed the normal amplitude of the sync pulses.

The negative polarity signal from the noise cancellation tube and the positive polarity signal from the first video amplifier are combined at the junction of R_{216} and R_{212}. Since noise pulses are the only signal that can exceed the amplitude of the sync pulses, the output of the noise cancellation tube is negative noise pulses that combine with and cancel the positive noise pulses from the plate circuit of the first video amplifier. The resultant signal is then fed through C_{188} to the grid of first sync amplifier V_{107A}. After being clipped and amplified by V_{107A}, the negative polarity sync pulses are further amplified by V_{110A} and appear as positive polarity sync pulses in the plate circuit of V_{110A}.

From the junction of R_{148}, R_{149}, and C_{142}, positive pulses are fed through C_{153} to the grid of the horizontal oscillator control tube, pin 2 of V_{112}. Also fed to the grid, through C_{154} and R_{167}, is a sample of the horizontal sweep voltage. The two signals control the conduction of the left hand triode of the 6CG7 (V_{112}) which in turn, controls the frequency of the right triode which is connected as a blocking oscillator.

The remainder of the horizontal and high voltage circuits are practically the same as those circuits used in the Admiral and function in the same manner.

The vertical sweep circuit, however, includes some variations and warrants additional explanation. First, the sweep circuit is basically a plate coupled multivibrator with the plate of V_{110B} coupled to the grid of V_{111} through C_{150}. The plate of V_{111} is coupled to the grid of V_{110B} through R_{166}, C_{151}, C_{176}, R_{158}, R_{152}, and C_{145}. The vertical sawtooth voltage is developed across C_{147} and C_{149} and fed through C_{150} to the grid of the vertical output tube.

An interesting feature of this vertical sweep circuit is the manner in which bias is obtained for the 6AQ5. The negative voltage that is developed at the grid of the discharge tube is fed through R_{159} to Vertical Linearity Control R_{160}. The setting of this control determines how much of the negative voltage is applied to the grid of the 6AQ5 as bias.

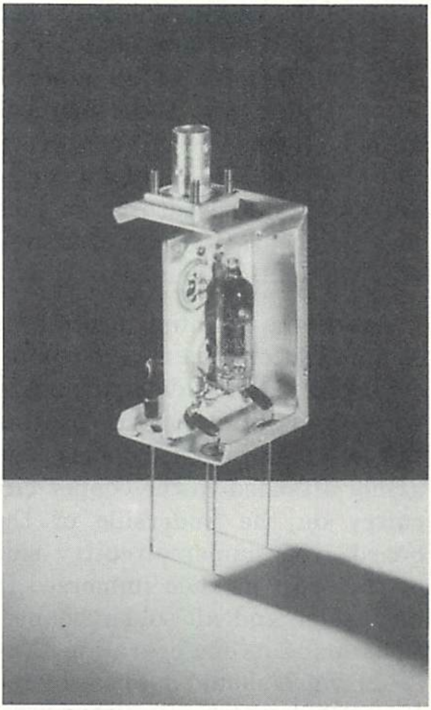
A vertical retrace blanking circuit also is incorporated in this receiver and a positive pulse, at the vertical sweep frequency, is applied to the cathode of the picture tube.

R160

Printed Circuits

The use of printed circuits is another feature of this receiver that is becoming increasingly popular. The sections of the receiver that are enclosed with broken lines are constructed on "printed-circuit" boards. The boards are made up as units and installed in the receiver chassis proper. For identification purposes on the diagram, these printed-circuit boards are labelled PC 101-A, PC 101-B, PC 102-C, etc.

The production of a printed circuit starts with a very thin sheet of copper being bonded to a plastic insulating material which is used as the "chassis" on which the circuit is constructed. A photographic negative is made of a drawing of the required circuit.



Printed circuit oscillator-detector for use in Citizens Band transmitter and receiver.
Courtesy Centralab.

Then, the copper sheeting is coated with a substance which makes it photo sensitive and a contact print of the negative is made on the copper sheeting. After development of the photographic image on the copper sheeting, it is placed in an etching solution which eats away the unexposed portions of the copper, leaving an accurate copper reproduction of the desired circuit.

Since the original negative can be used to make any quantity of units, uniformity of all units is assured. Recently, these methods have been used with such precision that line widths of copper as fine as one-hundredth of an inch can be accurately manufactured on a production line basis.

After the etching process is completed, components are mounted on the plastic side of the board with their lead lengths passing through pre-punched holes and firmly attached to the copper circuitry on the underside of the board. The copper circuitry side of the board is then immersed in hot solder and all solder connections made in one operation. Any leads which should not be soldered are coated with a glass fibre insulation before the dipping operation.

Printed circuit techniques have several advantages over the point-to-point wiring methods. Among these are more consistent high quality, simplification of receiver construction and reduced costs.

An example of this type of construction is shown in Figures 16 and 17. Figure 16 is a view of the component side of a printed circuit board used in an Admiral TV receiver, which shows the simplicity of construction. Figure 17 is the wiring side of a printed circuit board mounted to a TV chassis. Notice that the usual maze of insulated wires is missing, and leads connect to points along the edge of the board.

The RCA receiver (Figure 15) employs the same type of construction with the difference being that the circuits are made up in smaller assemblies and the assemblies are then mounted on the receiver chassis. It should be remembered that, as far as the electrical circuits are concerned, receivers using printed circuits are no different than receivers not using printed circuits.

A GENERAL ELECTRIC TV RECEIVER

To further illustrate a modern TV receiver, Figures 18 and 19 are the block diagram and schematic diagram, respectively, of the General Electric "N" chassis series of receivers. The block diagram of Figure 18 shows that the basic circuitry for this receiver is very similar to that of the preceding receivers described in this lesson. The main difference lies in the agc system.

The schematic diagram (minus the tuner detailed circuitry) of Figure 19 shows that the output of the third i-f amplifier (V_{105}) is detected by the crystal rectifier (Y_{150}), and the video signal is fed to the grid of the first video amplifier V_{106A}. Since the output of the detector is a negative polarity signal, the ungrounded end of R_{161} provides a pulsating negative direct voltage. The pulsations are filtered out by R_{163}, C_{162}, R_{162} and C_{161}, and the negative voltage is fed to the grids of the first two i-f amplifiers and to the grid of the r-f amplifier in the tuner.

The agc clamping diode, V_{113C}, has its plate connected to the junction of C_{162} and R_{162} to prevent the agc voltage from becoming positive. Should a loss of signal occur, or if one of the controlled tubes become gassy, the polarity of the voltage at pin 6 of V_{113C} tends to go positive. When this occurs, the diode conducts and, since the plate of this diode is at practically the same voltage as the cathode when it conducts, the plate and all points connected to it are placed at ground potential.

A positive voltage is fed into the agc line through R_{179} and R_{180} which, due to the large values of R_{179} and R_{180}, is a small voltage. The purpose of this small positive voltage is to cancel out the agc voltage that is developed by weak signals and increases the sensitivity of the receiver. When a large signal is being received, the agc voltage is of sufficient amplitude that this small positive voltage has very little effect.

Positive polarity video is taken from the junction of L_{172} and L_{174}, in the plate circuit of V_{106A}, and fed through RC networks to the grid of sync clipper V_{106B}. The grid and cathode of V_{106B} act as a diode and rectify the composite signal. A negative voltage is developed at the right hand plate of C_{202} and the bottom plate of C_{201} which is sufficient to bias the sync clipper (V_{106B}) so that only the positive sync pulses can cause plate current. This action eliminates the video information and allows only the sync pulses to appear in the plate circuit.

Besides preventing the video information and the blanking pulses from causing plate currents in V_{106B}, the negative voltage developed in the grid circuit of the sync clipper is fed through R_{202} to the agc system and combined with the detector (d-c) output voltage.

From the output of the sync clipper, negative sync pulses are fed through the integrator network to the vertical scanning system (V_{108}) which consists of a plate coupled multivibrator. Since this circuit is very much like the vertical system used in Figure 15, no further explanation is given.

Negative sync pulses are applied to the cathode of the triode phase detector, V_{107A}, along with a sawtooth voltage derived from the horizontal output transformer. If the horizontal oscillator tends to go off frequency, a correction voltage is obtained at the grid of V_{107A} and applied to the grid of horizontal multivibrator V_{109} to keep it on frequency.

As indicated on the diagram, the PHASE BALANCE CONTROL R_{252} adjusts for equal voltages at the plate and grid of V_{107A} with no signal input. This balances the plate and grid current and enables the negative sync pulses, applied to the cathode, to cause equal current in both circuits.

The oscillator, the horizontal output, and high voltage circuits of Figure 19 are very similar to the circuits previously described for Figure 13.

CONTROLLED WARM-UP HEATERS

Of considerable interest in this particular receiver is the low voltage power supply. An autotransformer steps up the line voltage to about 175 v a-c and the rectified output is about 215 v d-c. Instead of using a separate filament transformer, however, the autotransformer is tapped down to 86 v a-c which is used to supply the series connected heaters.

In older model receivers, using series connected heaters, some of the tubes would have an excessive voltage developed across their filaments due to the fact that some tubes would warm up faster than others. Since the resistance of the filament increases as it warms up, the slow heating tubes would have less than normal voltage across their filaments and the excessive voltage would be "dropped" across the fast warm-up tubes. This condition produced a higher than normal voltage across the quick heaters and resulted in many burn-outs.

To counteract this undesirable condition, manufacturers have developed tubes especially designed for series-string operation. The heater current is standardized at 600 ma for series-string operation and the resistance of each heater is designed to give the proper heating power. Besides this qualification, the heaters of this special group of tubes are designed with a "controlled warm-up" time of about 11 seconds. Consequently, none of the "controlled warm-up" tubes in a series-string will have an excessive heater voltage and the number of burn-outs is reduced considerably.

The 11 second heater warm-up time does not mean that the receiver will "come to life" in 11 seconds as the amount of time necessary to transfer the heat from the filament to the cathode is several times greater than this. On the average, the receiver will come to life in 40 or 50 seconds.

In order to identify the controlled warm-up tubes, a change has been made in the heater voltage prefix number. For example: the 3AU6 is the series-string version of the 6AU6. The 6AU6 requires 6.3 volts at 300 ma while the new 3AU6 requires 3.15 volts at 600 ma. The 6AQ5 requires 6.3 volts at 450 ma while the new 5AQ5 requires 4.7 volts at 600 ma.

For those tubes that originally required 6.3 volts at 600 ma, a new suffix letter is added to their type numbers to indicate that they are in the new controlled warm-up family. The 6SN6GTA, for example, has been changed to 6SN7GTB and the 6S4 has been changed to 6S4A.

SERVICING NOTES

Where servicing is concerned, receivers employing series-string heaters are analyzed in a different manner than those using parallel heaters. For example, if the heater of tube V_9 in Figure 13 were to open, the indication would be a loss of sound and the difficulty could immediately be pinpointed to those circuits which affect the sound.

However, if the heater of tube V_{113} of Figure 19 opens, all of the other tubes do not heat and the receiver is completely dead. Naturally, this same condition occurs if any of the tubes in the series-string should have an open heater. Thus it becomes necessary to check the heater of each tube individually or to make resistance checks of series-string to locate the defective tube.

For troubles besides open heaters, the symptoms will be the same as for a receiver that uses parallel-connected heaters. For example, if R_{167} (which is in the plate and screen circuits of V_{103}) should open there would be no picture or sound present but the raster would be normal. Or, if C_{205} should short, the result would be a loss of vertical synchronization as this capacitor would short out the sync pulse that is applied to the vertical oscillator. Finally, if R_{266} should open, no horizontal pulse would be fed to the phase detector and the result would be a loss of horizontal synchronization.

As mentioned in earlier lessons, the details of servicing and maintenance of TV and radio receivers are offered in later assignments. The first of this series begins with the next lesson.

IMPORTANT DEFINITIONS

CONTROLLED WARM-UP TUBES—Tubes developed for series-string operation. The filaments all require 600 ma and are designed to reach normal operating temperature in about 11 seconds.

AGC—A system of feeding back a bias voltage to the grids of the r-f and i-f amplifier tubes that is directly proportional to the strength of the received signal. In this way the gain of the controlled stages can be made to vary inversely proportional to the strength of the received signal.

AMPLIFIED AGC—The same principle as agc with the addition of a stage which amplifies the bias voltage before it is applied to the controlled stages.

KEYED AGC—A system whereby the agc bias voltage is developed by a tube that is keyed on during the horizontal sync pulse interval by a keying pulse from the horizontal flyback transformer.

VERTICAL RETRACE BLANKING—A circuit used to bias the picture tube to beam current cutoff during the vertical retrace interval. This is accomplished by obtaining a positive pulse from the vertical deflection system and applying it to the cathode of the picture tube or by obtaining a similar negative pulse and applying it to the grid.

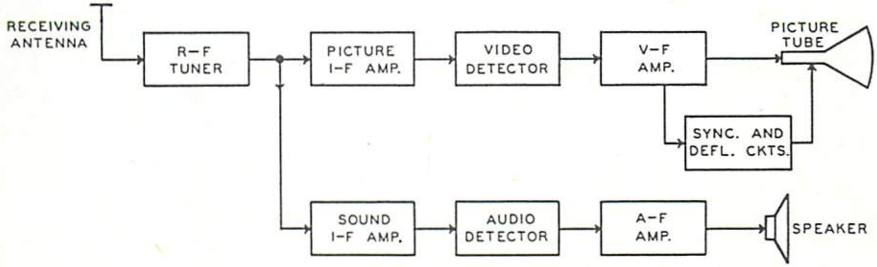


FIGURE 1

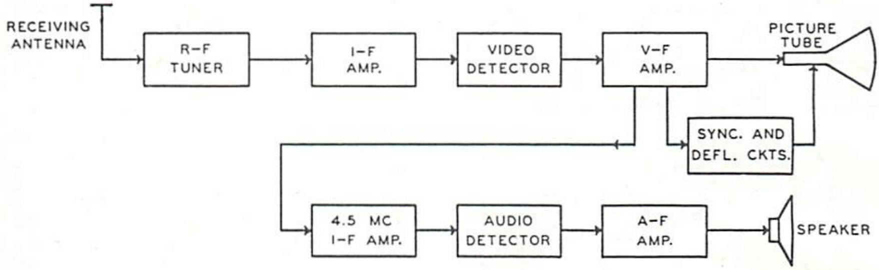


FIGURE 2

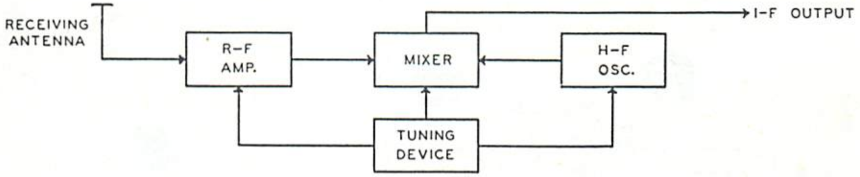


FIGURE 3

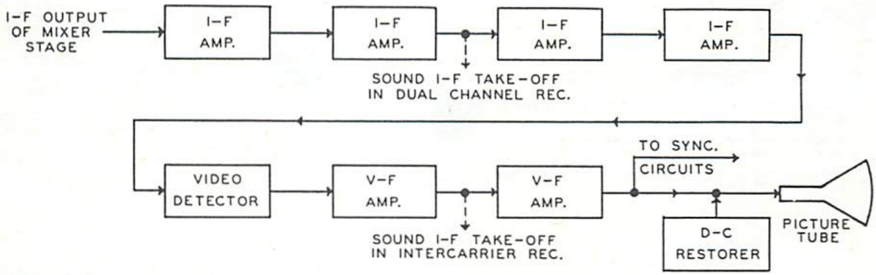

I-F OUTPUT OF MIXER STAGE
I-F AMP.
I-F AMP.
I-F AMP.
I-F AMP.
SOUND I-F TAKE-OFF IN DUAL CHANNEL REC.
VIDEO DETECTOR
V-F AMP.
V-F AMP.
TO SYNC. CIRCUITS
D-C RESTORER
PICTURE TUBE
SOUND I-F TAKE-OFF IN INTERCARRIER REC.

FIGURE 4

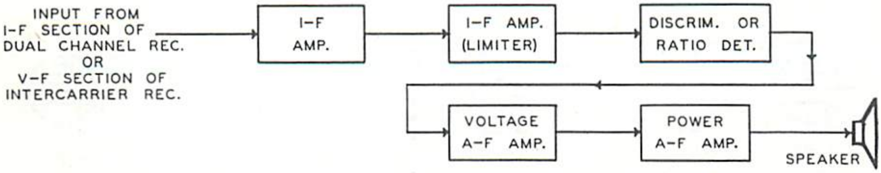


FIGURE 5

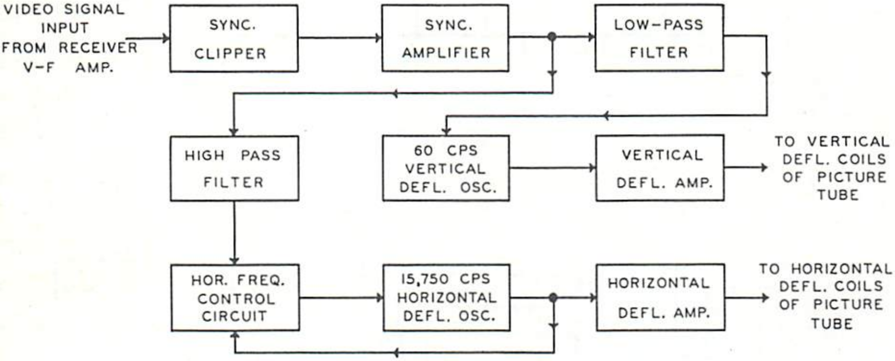


FIGURE 6

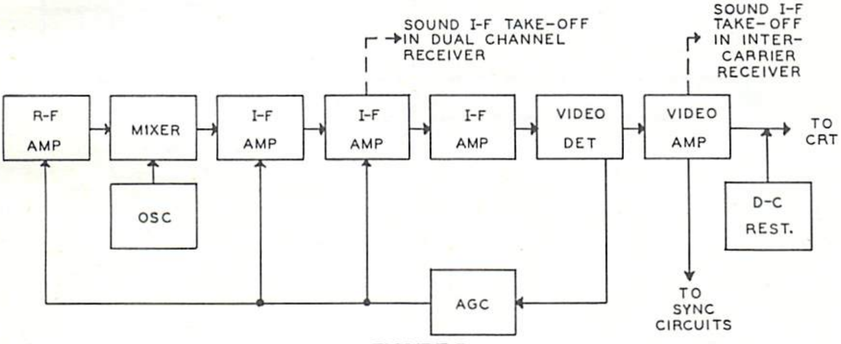


FIGURE 7

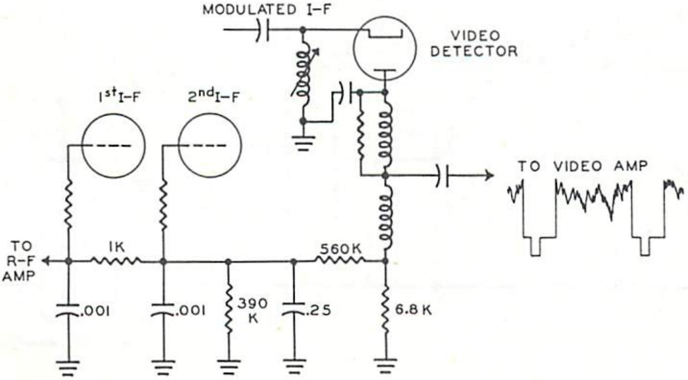


FIGURE 8

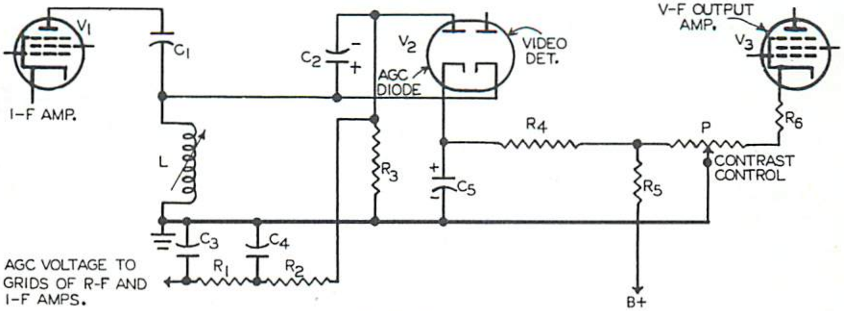


FIGURE 9

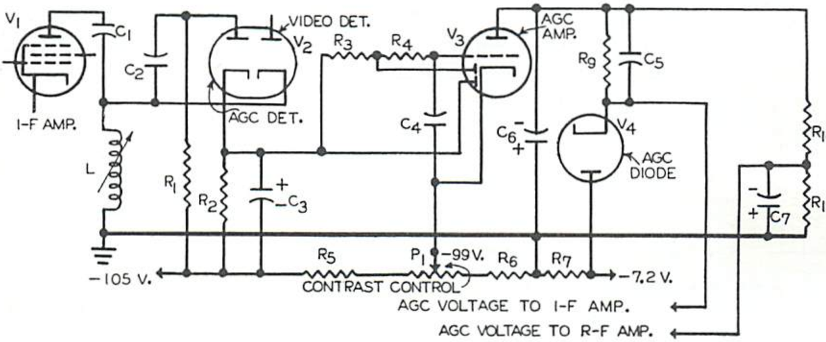


FIGURE 10

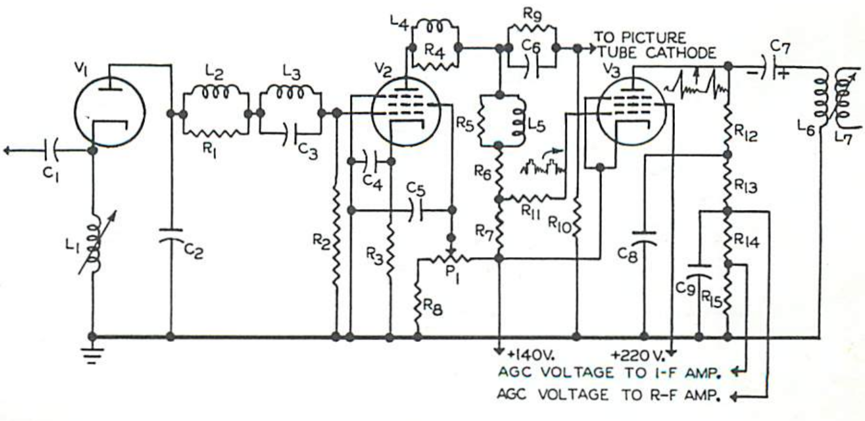


FIGURE 11

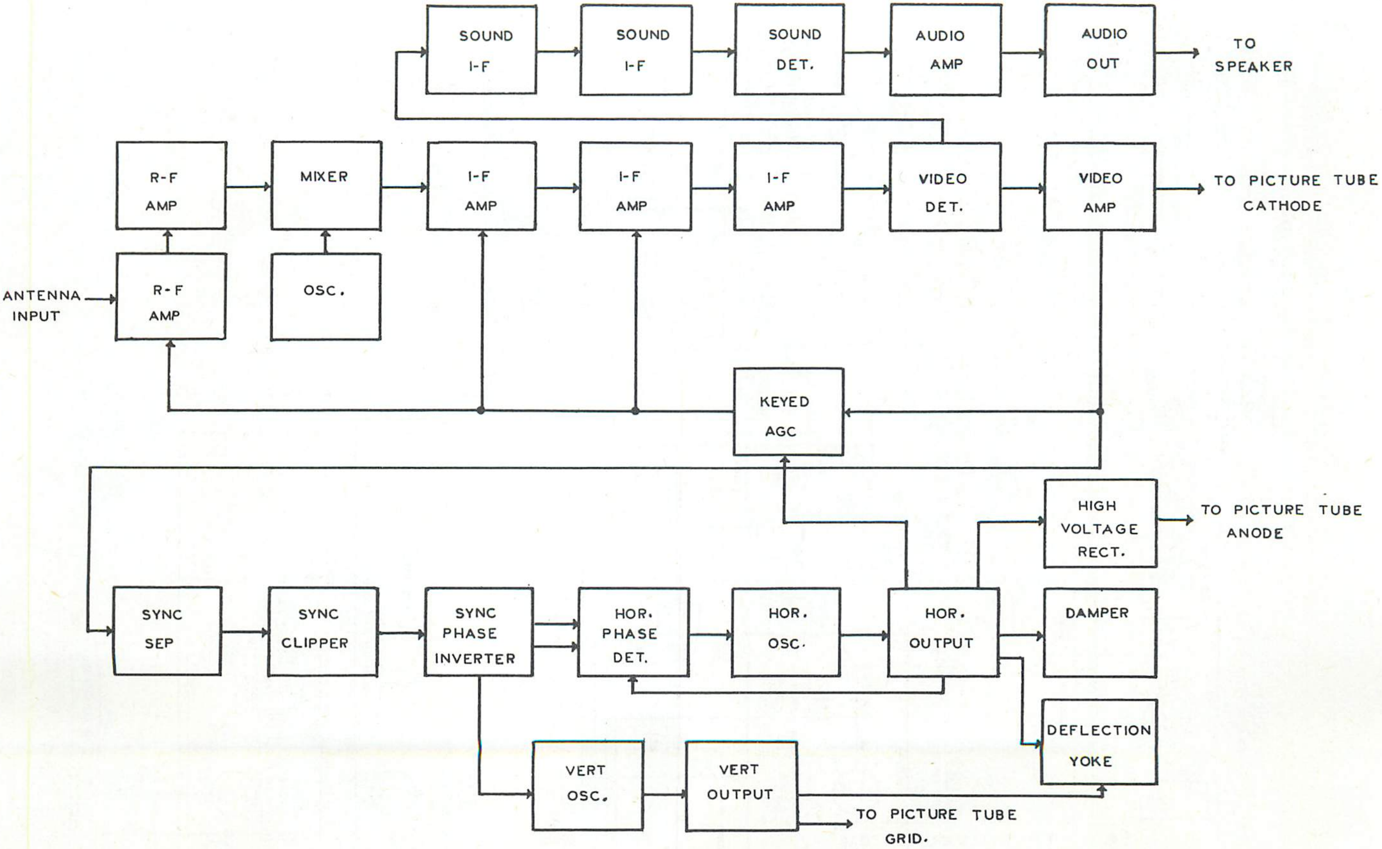
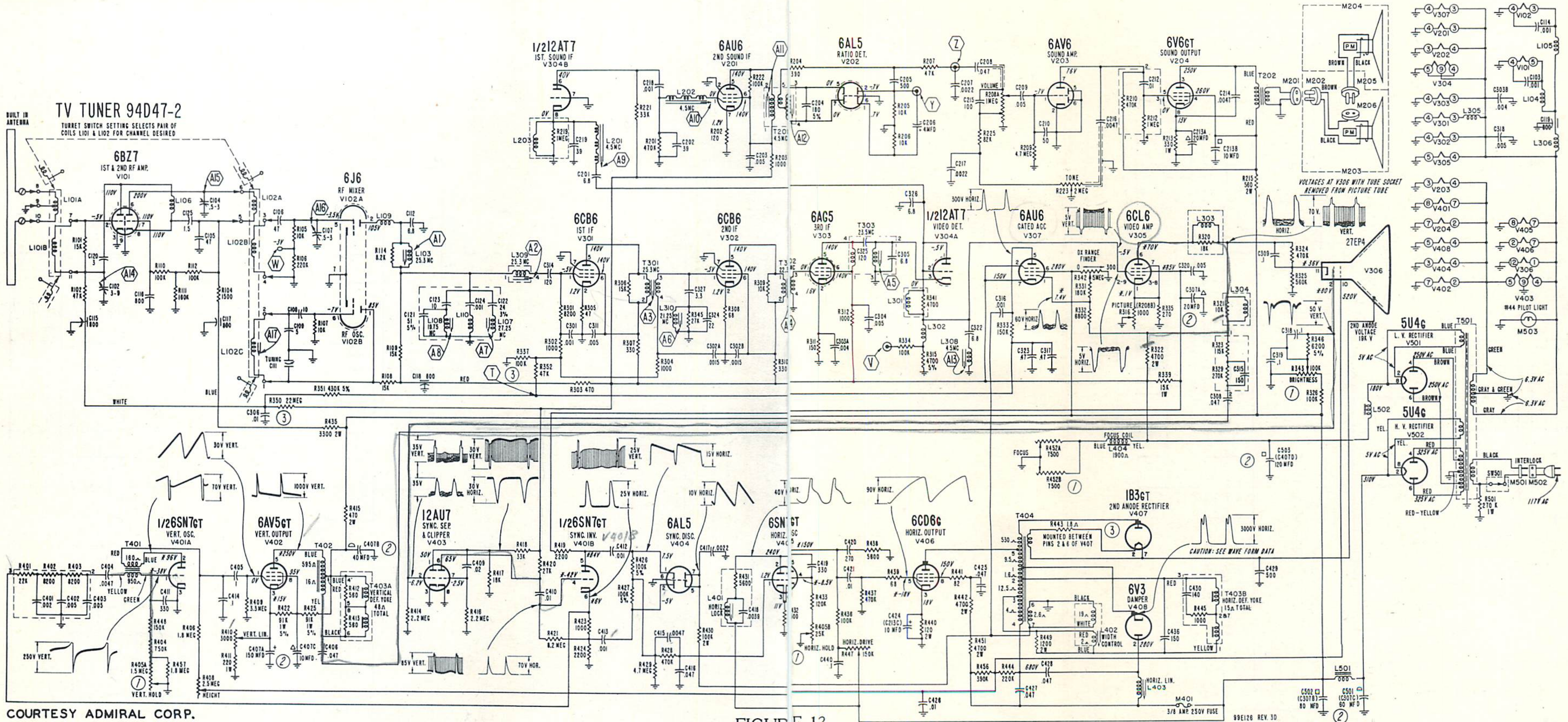

SOUND I-F
SOUND I-F
SOUND DET.
AUDIO AMP
AUDIO OUT
TO SPEAKER
R-F AMP
MIXER
I-F AMP
I-F AMP
I-F AMP
VIDEO DET.
VIDEO AMP
TO PICTURE TUBE CATHODE
ANTENNA INPUT
R-F AMP
OSC.
KEYED AGC
HIGH VOLTAGE RECT.
TO PICTURE TUBE ANODE
SYNC SEP
SYNC CLIPPER
SYNC PHASE INVERTER
HOR. PHASE DET.
HOR. OSC.
HOR. OUTPUT
DAMPER
DEFLECTION YOKE
VERT OSC.
VERT OUTPUT
TO PICTURE TUBE GRID.

FIGURE 12



COURTESY ADMIRAL CORP.

T2C-20

FIGURE 13

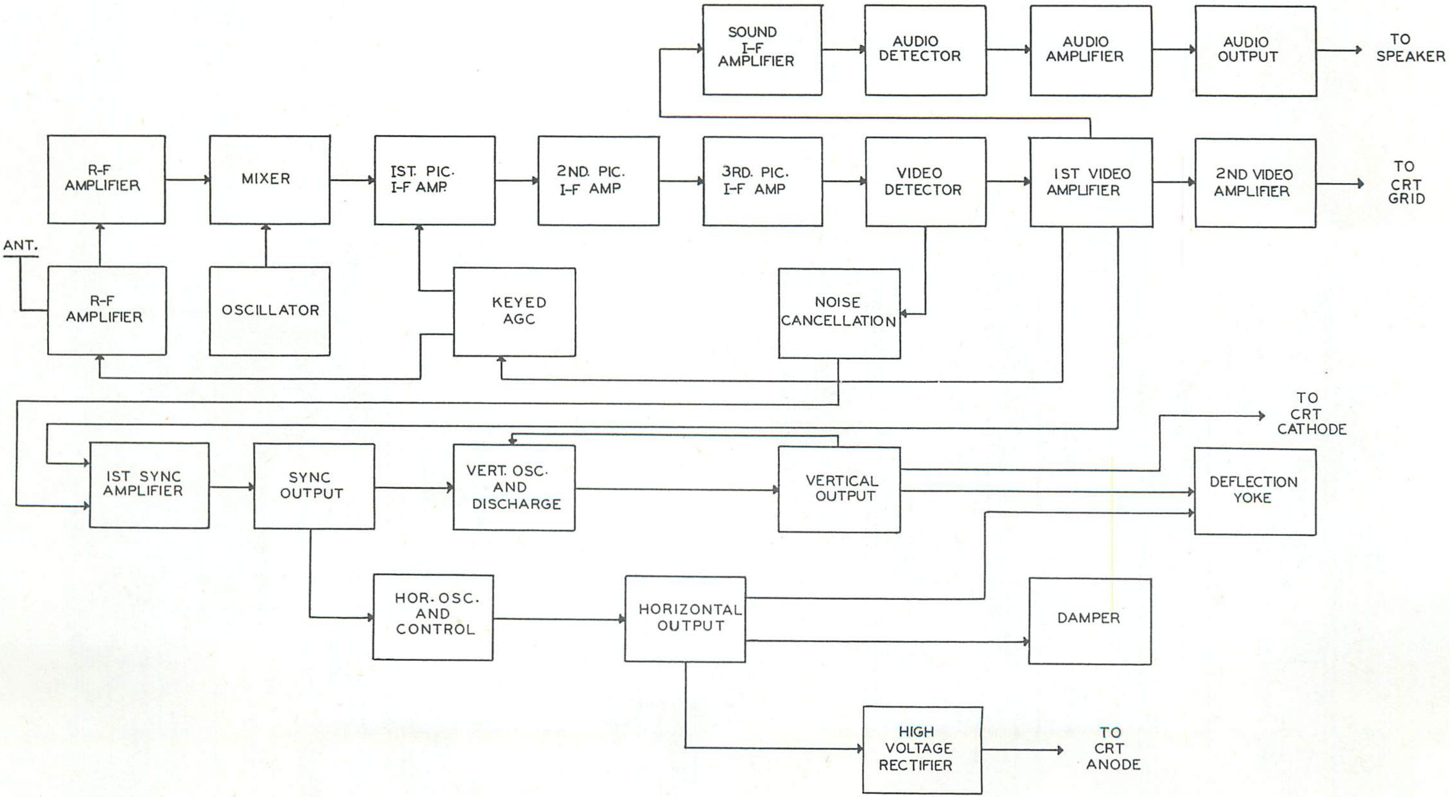
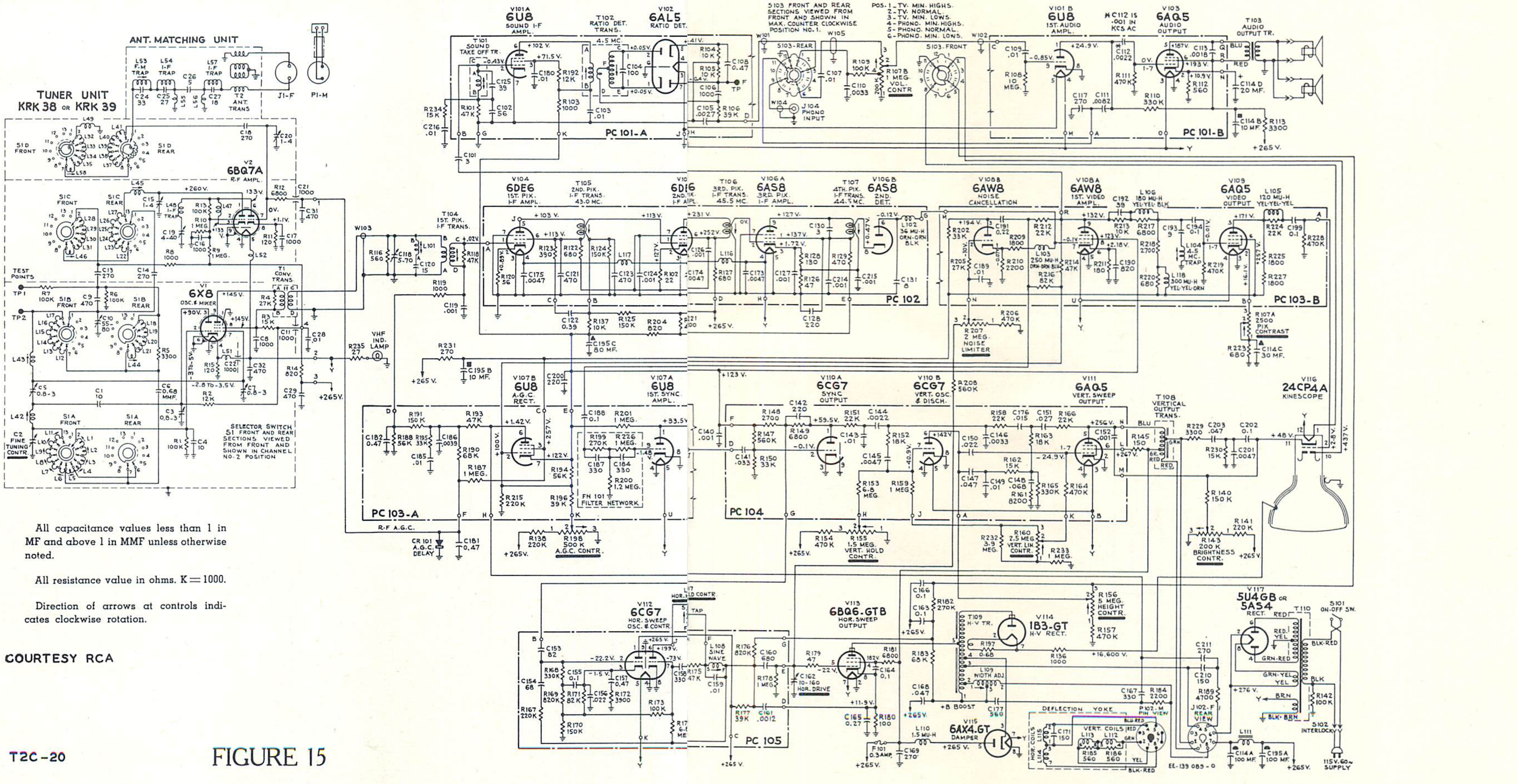

SOUND I-F AMPLIFIER
AUDIO DETECTOR
AUDIO AMPLIFIER
AUDIO OUTPUT
TO SPEAKER
R-F AMPLIFIER
MIXER
IST. PIC. I-F AMP.
2ND. PIC. I-F AMP
3RD. PIC. I-F AMP
VIDEO DETECTOR
IST VIDEO AMPLIFIER
2ND VIDEO AMPLIFIER
TO CRT GRID
ANT.
R-F AMPLIFIER
OSCILLATOR
KEYED AGC
NOISE CANCELLATION
TO CRT CATHODE
IST SYNC AMPLIFIER
SYNC OUTPUT
VERT. OSC. AND DISCHARGE
VERTICAL OUTPUT
DEFLECTION YOKE
HOR. OSC. AND CONTROL
HORIZONTAL OUTPUT
DAMPER
HIGH VOLTAGE RECTIFIER
TO CRT ANODE

FIGURE 14


ANT. MATCHING UNIT
TUNER UNIT
KRK 38 OR KRK 39
J1-F
P1-M
V2 6BQ7A R-F AMPL.
V1 6X8 OSC. & MIXER
T1 CONV. TRANS.
TEST POINTS
TP1
TP2
C2 FINE TUNING CONTR.
SELECTOR SWITCH S1 FRONT AND REAR SECTIONS VIEWED FROM FRONT AND SHOWN IN CHANNEL NO. 2 POSITION
VHF IND. LAMP
W103
R-F A.G.C.
CR101 A.G.C. DELAY
V101A 6U8 SOUND I-F AMPL.
T101 SOUND TAKE OFF TR.
T102 RATIO DET. TRANS.
V102 6AL5 RATIO DET.
PC 101-A
S103 FRONT AND REAR SECTIONS VIEWED FROM FRONT AND SHOWN IN MAX. COUNTER CLOCKWISE POSITION NO. 1.
POS.-1-TV. MIN. HIGHS. 2-TV. NORMAL. 3-TV. MIN. LOWS. 4-PHONO. MIN. HIGHS. 5-PHONO. NORMAL. 6-PHONO. MIN. LOWS.
J104 PHONO INPUT
R107 B 1 MEG. VOL. CONTR
V101 B 6U8 1ST. AUDIO AMPL.
C112 IS .001 IN KCS AC
V103 6AQ5 AUDIO OUTPUT
T103 AUDIO OUTPUT TR.
PC 101-B
V104 6DE6 1ST. PIX. I-F AMPL.
T104 1ST. PIX. I-F TRANS.
T105 2ND. PIX. I-F TRANS. 43.0 MC.
V105 6DE6 2ND. PIX. I-F AMPL.
T106 3RD. PIX. I-F TRANS. 45.5 MC.
V106A 6AS8 3RD. PIX. I-F AMPL.
T107 4TH. PIX. I-F TRANS. 44.5 MC.
V106B 6AS8 2ND. DET.
PC 102
V108B 6AW8 NOISE CANCELLATION
R207 2 MEG. NOISE LIMITER
V108A 6AW8 1ST. VIDEO AMPL.
V109 6AQ5 VIDEO OUTPUT
R107A 2500 PIX CONTRAST
PC 103-B
V107B 6U8 A.G.C. RECT.
V107A 6U8 1ST. SYNC AMPL.
FN 101 FILTER NETWORK
R198 500 K A.G.C. CONTR.
PC 103-A
V110A 6CG7 SYNC OUTPUT
V110B 6CG7 VERT. OSC. & DISCH.
R155 1.5 MEG. VERT. HOLD CONTR.
PC 104
V111 6AQ5 VERT. SWEEP OUTPUT
R160 2.5 MEG VERT. LIN. CONTR.
T108 VERTICAL OUTPUT TRANS.
V116 24CP4A KINESCOPE
R143 200 K BRIGHTNESS CONTR.
V112 6CG7 HOR. SWEEP OSC. & CONTR.
L117 HOR. HOLD CONTR.
L108 SINE WAVE
C162 10-160 HOR. DRIVE
PC 105
V113 6BQ6-GTB HOR. SWEEP OUTPUT
T109 H-V TR.
V114 1B3-GT H-V RECT.
L109 WIDTH ADJ.
R156 5 MEG. HEIGHT CONTR.
V115 6AX4-GT DAMPER
DEFLECTION YOKE
J102-F REAR VIEW
P102-M PIN VIEW
V117 5U4GB OR 5AS4 RECT.
T110
S101 ON-OFF SW.
S102 INTERLOCK
115 V. 60~ SUPPLY
EE-139 089-0
+265 V.
+16,600 V.

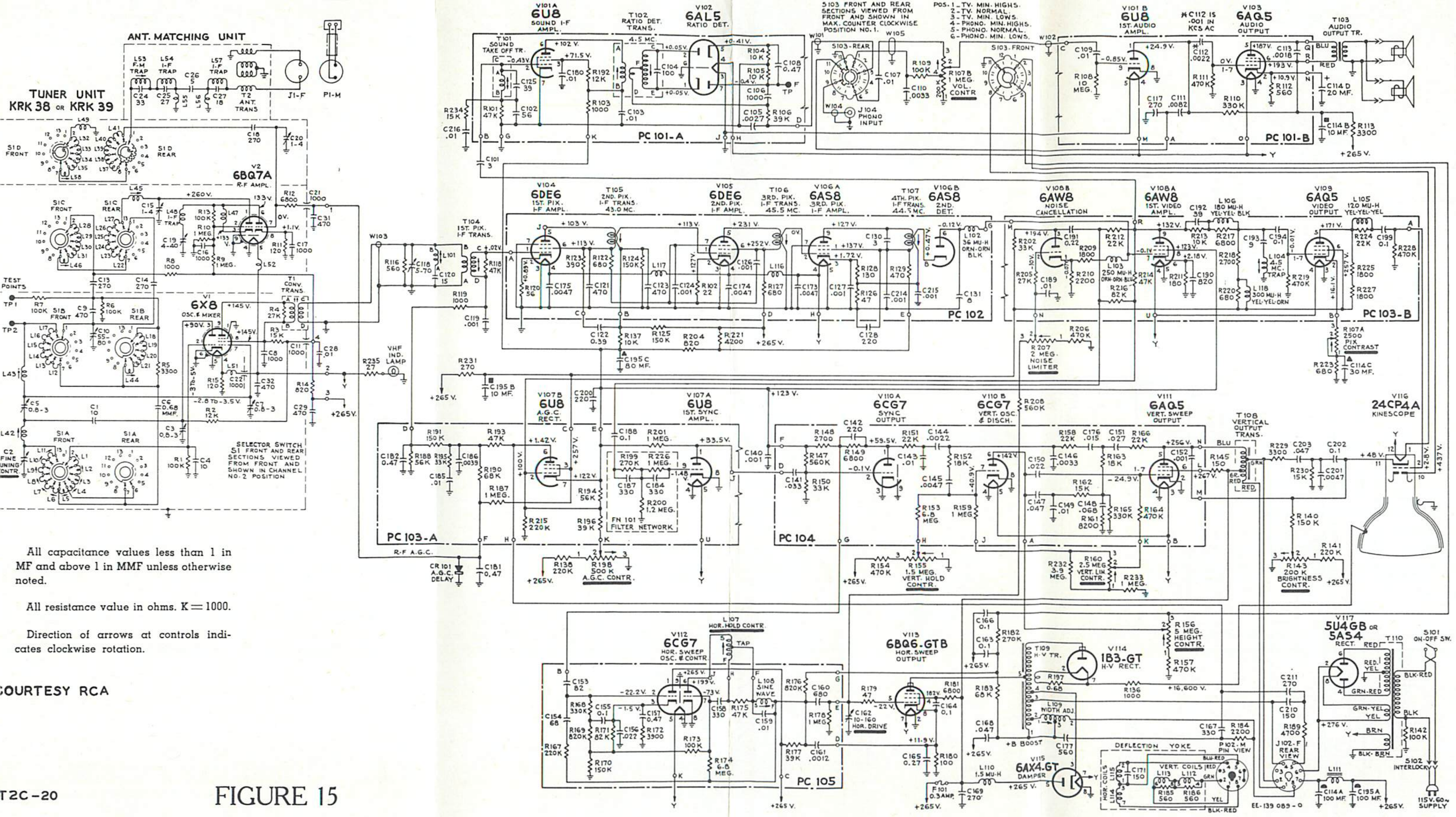
All capacitance values less than 1 in MF and above 1 in MMF unless otherwise noted.

All resistance value in ohms. K = 1000.

Direction of arrows at controls indicates clockwise rotation.

COURTESY RCA

FIGURE 15



All capacitance values less than 1 in MF and above 1 in MMF unless otherwise noted.

All resistance value in ohms. K = 1000.

Direction of arrows at controls indicates clockwise rotation.

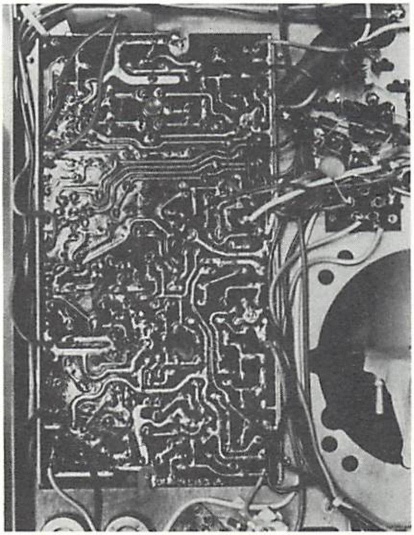
COURTESY RCA

T2C-20

FIGURE 15

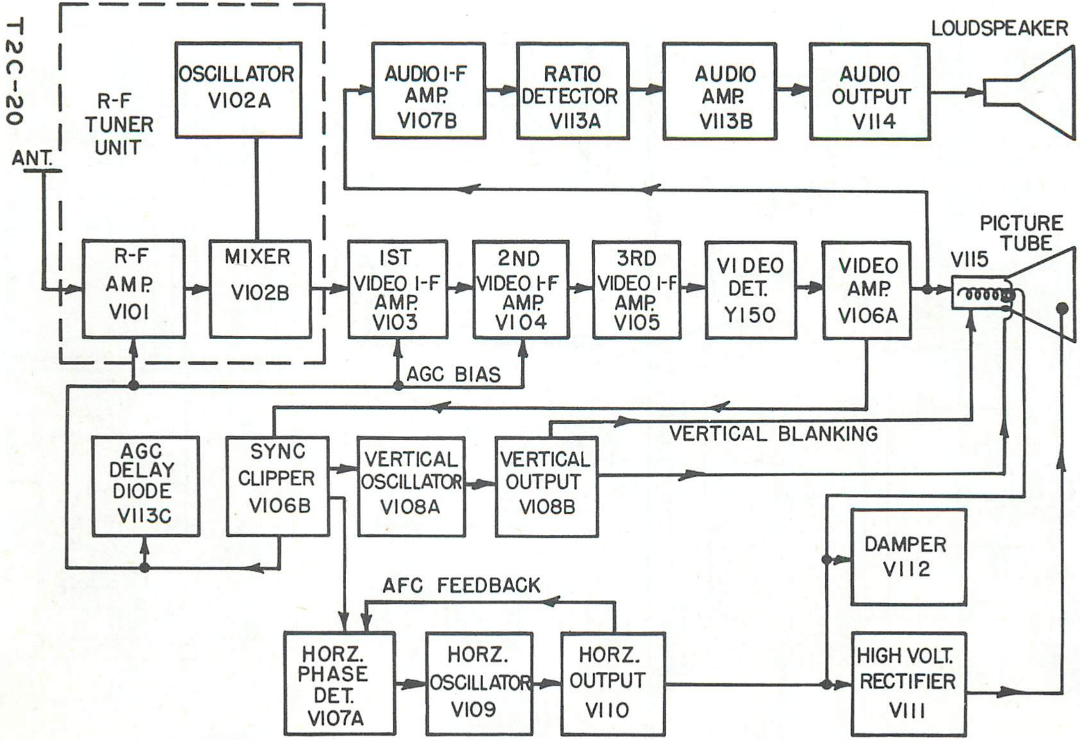
COURTESY ADMIRAL CORPORATION

FIGURE 16



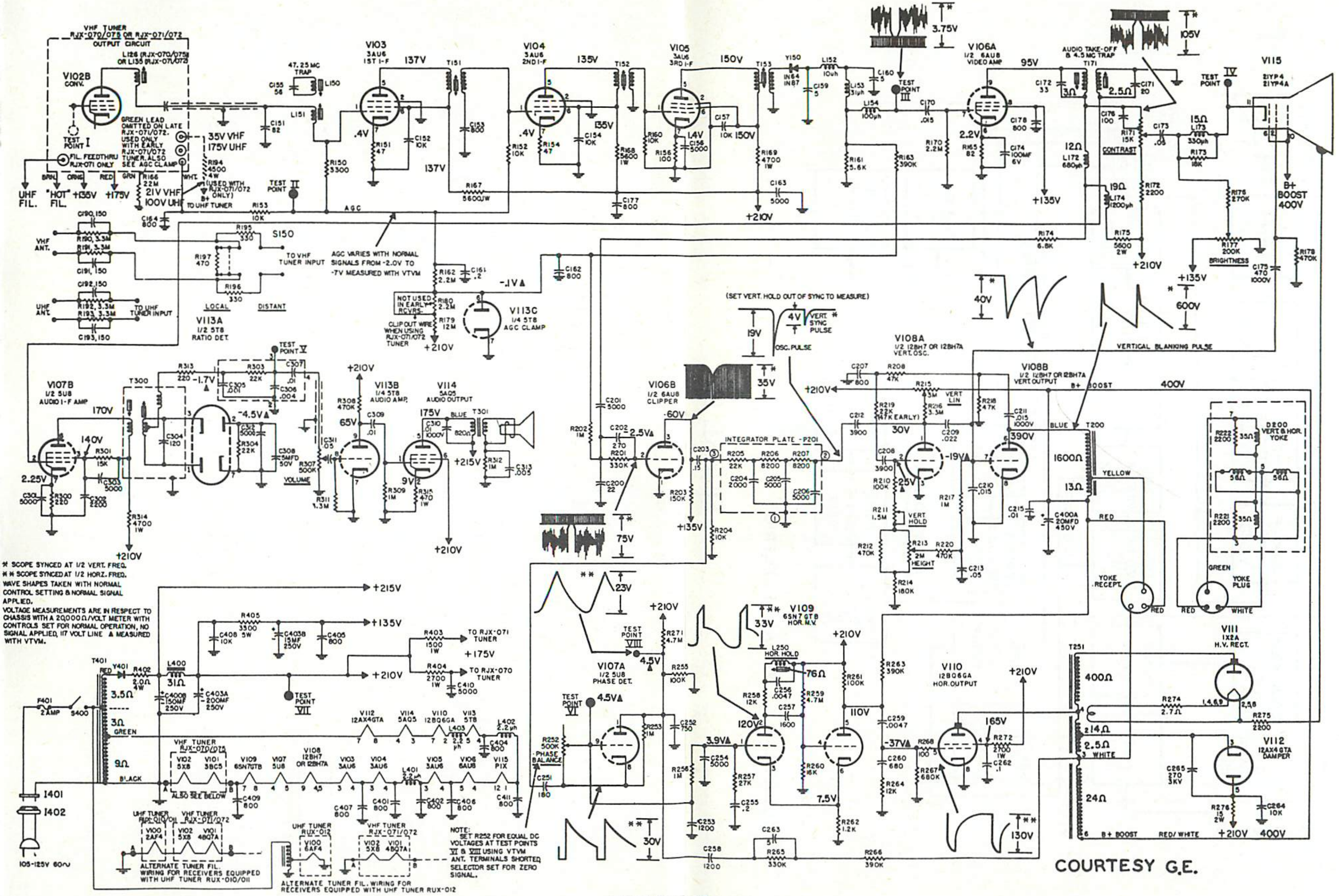
COURTESY ADMIRAL CORPORATION

FIGURE 17



COURTESY GENERAL ELECTRIC

FIGURE 18



* SCOPE SYNCED AT 1/2 VERT. FREQ.
** SCOPE SYNCED AT 1/2 HORZ. FREQ.
WAVE SHAPES TAKEN WITH NORMAL CONTROL SETTING & NORMAL SIGNAL APPLIED.
VOLTAGE MEASUREMENTS ARE IN RESPECT TO CHASSIS WITH A 20,000 Ω/VOLT METER WITH CONTROLS SET FOR NORMAL OPERATION, NO SIGNAL APPLIED, 117 VOLT LINE ▲ MEASURED WITH VTVM.

NOTE:
SET R252 FOR EQUAL DC VOLTAGES AT TEST POINTS VI & VIII USING VTVM ANT. TERMINALS SHORTED SELECTOR SET FOR ZERO SIGNAL.

COURTESY G.E.

FIGURE 19

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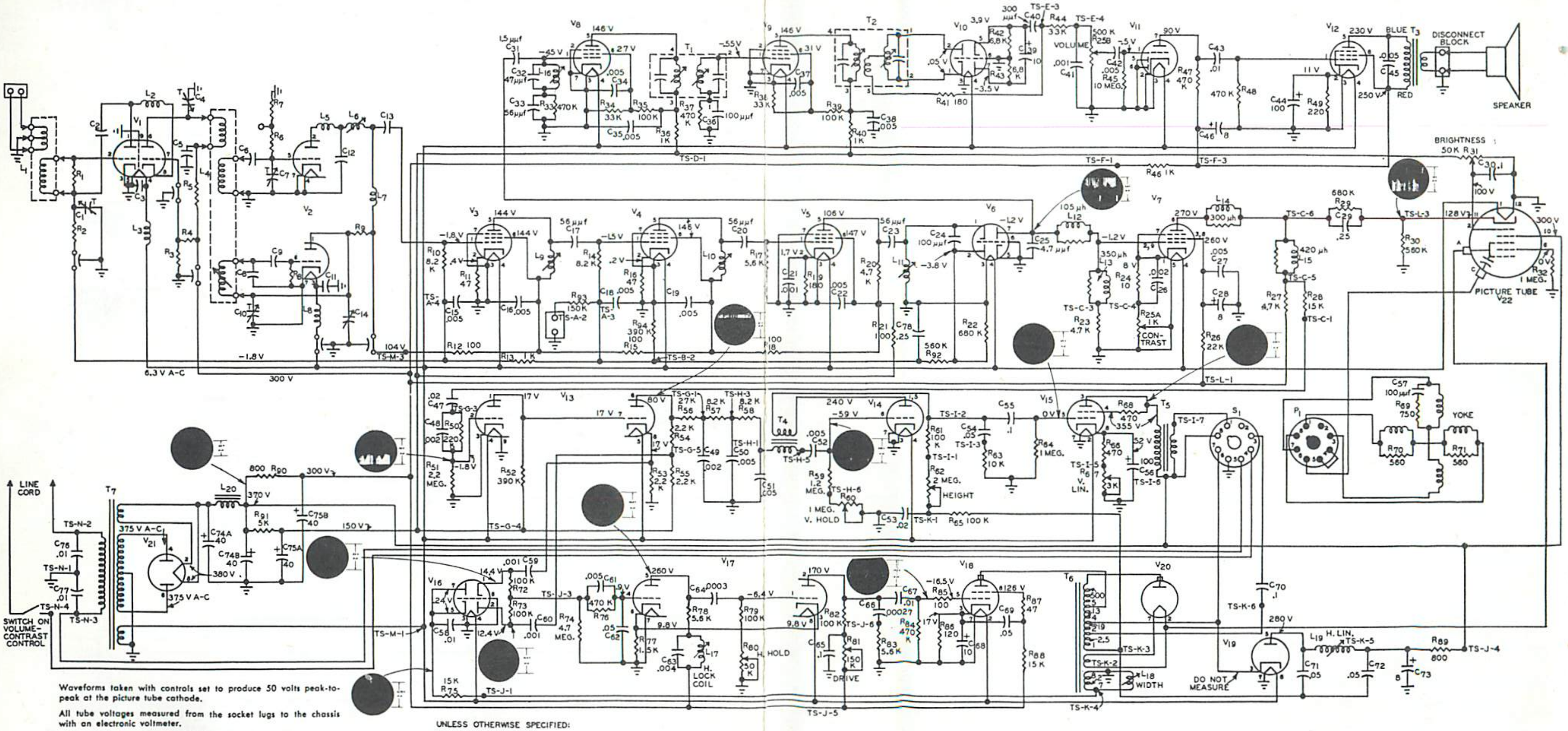
WORK DIAGRAM

Figure 20 is the schematic diagram of a TV receiver designed for DTI's home study training program. Referring to Figures 12, 14 and 18, in the space below draw a block diagram of the DTI receiver. Label all blocks as to function and include the tube number (V_1, V_2, etc.) used for each stage. (In order to gain maximum benefit from this work diagram, DO NOT refer to the solution until you have completed this project.)



Waveforms taken with controls set to produce 50 volts peak-to-peak at the picture tube cathode.

All tube voltages measured from the socket lugs to the chassis with an electronic voltmeter.

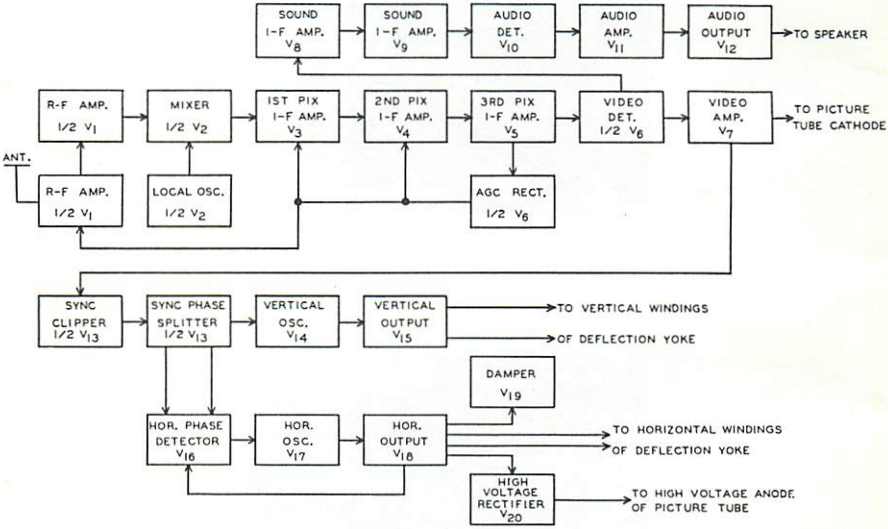
Volume and Contrast controls fully counterclockwise, no signal applied. Line 117 V a-c.

T2C-20

UNLESS OTHERWISE SPECIFIED:
RESISTANCES IN OHMS
CAPACITANCE IN µf

The completed block diagram solution is found on the reverse side of a fold-out sheet.

WORK DIAGRAM SOLUTION



FROM OUR *Director's* NOTEBOOK

WHY ARE WE ON THIS EARTH?

To help the rest who are on it, not only humans, but "everything that hath life." To show affection, to win friendship. To help the weary with their loads, to encourage and comfort and inspire. To make everyone about us feel the better and not the worse for our existence. To do our utmost to make all lives directly influenced by us a bit less burdensome, a bit happier and more worth while.

From that, if we have any imagination, we shall widen our activity so as to include those outside our personal range. We shall work for the overthrow everywhere of oppression, of unjustifiable privilege. We shall demand a square deal for everybody. We shall put our shoulders to all wheels that are being pushed out of the mud of traditional incompetence and inhumanity on to the high road of progress.

And, being thus occupied, we shall cease to whimper about why we are on this earth. We shall know.

Yours for success,

W. C. De Vry

DIRECTOR

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